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The works of the Lord are great, sought out of all them that have pleasure therein.—Ps. cxi, 2.

THE SIDEREAL MESSENGER.

MAY, 1891.

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WM. W. PAYNE, EDITOR,

Director of Carleton College Observatory.

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THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 10, No. 5. MAY, 1891. WHOLE No. 95

HOW TO MAKE GOOD MERIDIAN OBSERVATIONS.

TRUMAN HENRY SAFFORD.*

FOR THE MESSENGER.

SECOND ARTICLE.

Transit Observations for Local Time.

With a portable transit of two inches (French) in aperture local time can be determined with all the accuracy needful. If there are any exceptions they apply only to the highest class of telegraphic longitude work; in which, however, an aperture of 2½ inches (French) is amply sufficient.

With the smaller instrument mentioned a power of 70 is easily applicable; and if everything is in good order, and the chronographic method is used, the probable error of a time determination from six stars need not exceed $\pm 0^s.04$ or $\pm 0^s.05$, all elements included, even variability of personal equation. So that the employment of larger instruments is not necessary; their use may be, up to a certain point, a convenience.

But the excellence of the striding or hanging level must not only be guaranteed by the maker's reputation, but by careful investigation. Levels are apt to change their curvature, either really or apparently; and very embarrassing consequences may ensue. This Observatory has a Troughton & Simms level belonging to a disused instrument, which is more than half a century old. But when put on the level trier which I use for students' practice, it never fails to exhibit its admirable qualities as completely as when it was first made; certainly I know no better level tube of that age. If it were to be used in the Observatory, exposed to air currents, I should have it mounted in a newer way; but that does not detract from the conclusion that the tube itself is unharmed by its long existence.

* Professor of Astronomy, Williams College, Williamstown, Mass.

Sometimes I have met the suggestion, both in print and conversation, that observations for time might be reduced without any reference to the vertical. This is so absurd as to be hardly worth mentioning. Of course the fallacy lies (as one can show either by geometry or analysis) in the fact that we thus get the clock-correction for an unknown meridian, distant from the place of observation by $i \sec \varphi$ in longitude, or, in other words, about 100 linear feet for every second of arc in the level correction. A least square solution shows this by the nullity of the last divisor. The computer who mentioned the possibility of such a least square solution which would give a clock correction without leveling, had probably made such errors in his computation that his last divisor came out unequal to zero. The very skillful astronomer who suggested this as possible in a published memoir was in all probability merely thoughtless. But some levels, as before indicated, break down utterly. This is possibly a consequence of physical or chemical changes inside the tube. In some cases impurities in the ether dissolve particles of the glass, loosen other particles, and they make the bubble sluggish by adhesion; and the cases in which I have noticed bad levels have been comparatively very numerous. In reducing observations (not my own) for latitude by the zenith telescope I have sometimes found that the apparent level-corrections seemed to have nothing at all to do with the observations. That is, the vertical axis of the instrument was probably pretty accurately adjusted; but as the instrument was turned about the level bubble moved by jerks, or in some very irregular way, so that the axis itself was steadier than the level; at least the omission of the level-corrections improved the latitude. The latest German zenith telescopes have two attached levels. In this case if one breaks down the probable errors of the latitudes will at once show which is the defective one.

But for an ordinary transit-level, a simple level-trier affords an excellent and readily applied control. The larger instruments need more complicated level-triers; or else the dismounting of the glass tube. Professor Bruns of Leipsic has had constructed a large and fine level-trier (at a good deal of expense, I presume) by which to test the level of his meridian circle without taking it apart; but this is hardly practicable in ordinary cases.

XUM

The first maxim, then, of the observer who is determining absolute time is to look sharply after the level.

A portable transit of any size ought to be reversed smoothly enough not to change its azimuth. In such cases the collimation can be obtained in two nearly independent ways. The close polars will give it, without much dependence on the accuracy of the clock, on the assumption that reversal does not change the azimuth, and the stars near the zenith will give it, without much dependence on the stability in azimuth, on the assumption that the clock rate is regular.

If the instrument is but newly put up at a distant station, it is safer to rely upon a good time-piece than upon its fixity; the freshness of the cement in the piers is sometimes apt to lessen the stability.

The continental astronomers usually determine the collimation (for longitude observations) by reversal on a slow-moving star; taking some wires in the one position, and some in the other. This requires very good spider-lines, such as are inserted by the Repsolds; or a glass-scale finely cemented to the instrument; it also assumes great stability; and the assumption is usually warranted.

On the other hand the Coast Survey officers depend almost entirely upon the time stars for their collimation; and do not assume the identity of the azimuths before and after reversal. I have elsewhere given reasons for thinking it best to observe few stars below pole or south of the equator in determining longitude.

About one star near the pole to three or four near the zenith gives for our latitudes, the best practical balance, and the maximum of weight in proportion to the time spent in observing. If stars near the zenith only are observed for time, the result of the final solution is apt to show a diminished weight owing to uncertainty in azimuth, or, in other words, it becomes difficult to make the best selection of stars for the purpose.

Every complete time determination where exact results are required should be made partly in each of the two reversed positions of the instrument; and it is a good rule to select such combinations of stars that if it clouds up before reversal the evening's work will not be lost from want of either polars or time-stars in the one position; as the collimation

can usually be obtained, if need be, by interpolation or reversal on a terrestrial mark.

The security of a time determination to a few hundredths of a second depends, however, mainly upon exact and critical knowledge of the particular instrument. This can best be obtained by experience with it. A great many longitude observations in this country have been far less accurate than they need have been, from want of this precaution. A little experience may here illustrate the principle. In determining the longitude of Evanston, Wyoming, for the purpose of establishing the southwest corner of the territory, I had an instrument of rather light construction and poorly mounted. But it had just been employed in the prime vertical to determine latitudes on the parallel of 41° at about six stations; and the very skillful observer who had used it, and who was to take one end of the longitude work, exchanging stations with myself in the middle of the series, had learned its peculiarities and how to counteract them. The chief trouble was that the plank, not very well seasoned, on which the instrument rested "curled up" in the day time from the heat of the air, and at night gradually became flatter. Hence we took care to divide our stars into small groups of three or four, a polar and two or three time stars, and to reverse and adjust the level between groups; working as rapidly as possible. This threw the greater strain upon the star catalogues. I had, fortunately arranged the prime vertical list according to Bessel's method, east and west stars alternately, but not waiting for the west transit of the same star observed in the east; so that the method used in the prime vertical where the same instrumental peculiarity had shown itself, was quite adequate to the problem. Both the latitudes and the longitude were found quite needlessly accurate, as the contractor's topographical work was far from carefully done. The astronomical work was nearly as good as if the transit had been far better. This happened nearly twenty years ago. Since that time the improvements in portable instruments, and (probably) the actual stock of good transits in the country have rendered it unnecessary to employ bad ones any longer.

There are many extant transits whose true place is in the class-room to exemplify the general form of the instrument,

or properly hung up in an astronomical museum of antiquities.

In teaching practical astronomy the first instrument employed is usually the portable transit. It is, on the whole, quite as well to use a rather small one; Bessel's Repsold transit, with which he determined latitudes in his arc of the meridian, has an aperture of 21 lines French, or less than 2 inches English. Such an instrument has to be very delicately handled; and if the pupil is worth teaching at all, he will thus gain in the carefulness of his manual work, and be also very apt to get as good results as if he had a larger transit to practice with. In this way he learns to use the larger instruments with equal care and delicacy; and so to get excellent results.

I also think very highly of the eye-and-ear method as a means of training, and usually require pupils to use that some months before employing the chronograph. The careful reduction of eye-and-ear and chronographic observations on different stars will serve to indicate how far the pupil has acquired constancy of personal equation.

The first thing to be learned in transit practice is to perform the series of operations involved in "taking time" in proper order and without hurry. Then follows the exact judgment of fractions (in eye-and-ear work) or of the instant of transit in chronographic; then the insertion of level readings and reversals at the right time; and lastly practice for the purpose of making the personal equation (which greatly depends upon sub-conscious mental processes) more nearly constant. Novitiate astronomers are usually too anxious about their single wires, and need to be especially cautioned that this is not the critical matter. The pupil will probably have learned the preliminaries of measurement (estimation of tenths, etc.) in the physical laboratory, or with the level and level trier. The instructor must at first arrange the programme of stars. But above all things let the student avoid hurry; let him go slowly at first and increase his pace by well-arranged exercises, little by little.

A PAIR OF ANCIENTS.

C. C. HUTCHINS.

FOR THE MESSENGER.

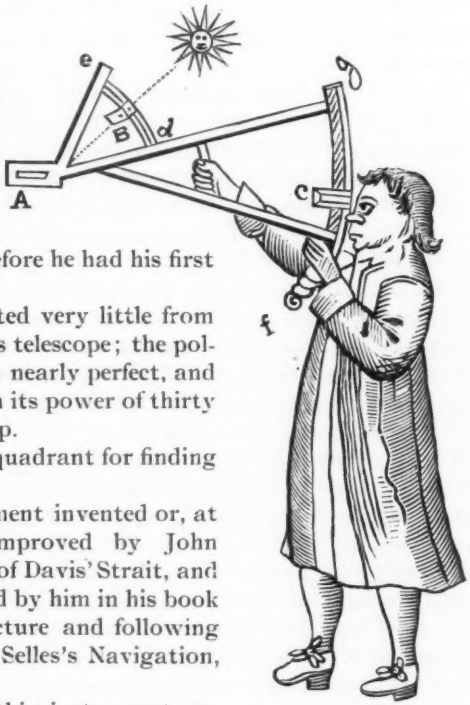
I have among my possessions two astronomical instruments whose age fairly entitles them to a measure of respectful notice. The first is a telescope—a Gregorian reflector; about eighteen inches long by two and a half in diameter. The tube is of heavy brass covered with black leather, now much worn, and on the eye-tube is engraved: "A^{s}. Mann, Ludgate Street, London, 1749.

It seems to have been just such an instrument that the elder Herschel loaned and used in his earliest observation; but it was twenty-five years later than the above date before he had his first telescope.

Age has detracted very little from the powers of this telescope; the polish of its mirror is nearly perfect, and the definition with its power of thirty is beautifully sharp.

The second is a quadrant for finding latitude at sea.

It is the instrument invented or, at least, greatly improved by John Davis, discoverer of Davis' Strait, and was first described by him in his book of 1594. The picture and following description from Selles's Navigation, 1699.



THE FIGURE OF THE QUADRANT AND MANNER OF OBSERVATION.

The parts of this instrument are principally three Vanes, and two Arches, which Arches together contain 90 degrees, and give it therefore the denomination of a quadrant.

Of the three Vanes. That which in time of observation respects the horizon, in this annexed figure represented by A, is called the horizon-vane; that which gives the shadow noted by B, is named the shadow-vane; and that through which you are to look for both shadow and horizon, distinguished with C, is called the sight-vane.

Of the Arches. The lesser noted with *de*, is named the sixty-arch because it contains but 60°, it is of small radius (advisedly so contrived) for the more apt placing of the Vane B thereon, that the shadow thereof falling upon the horizon-vane A, at this short distance might become the stronger and the more perspicuous to the eye of the observer. The greater Arch, here denoted by the letters *fg*, is called the thirty-arch, etc.

Rude as this device seems, it was the best in existence until as late as 1740, when it was superseded by Hadley's quadrant.

The instrument in my possession is made of rosewood and boxwood, is of very fine workmanship, tastefully carved. With its aid, after a little practice, I have been able to get the sun's altitude correct within one or two minutes; so that with fairly good solar tables the navigator should have been sure of his latitude within five miles.

THE ORBIT OF β DELPHINI (β 151.)

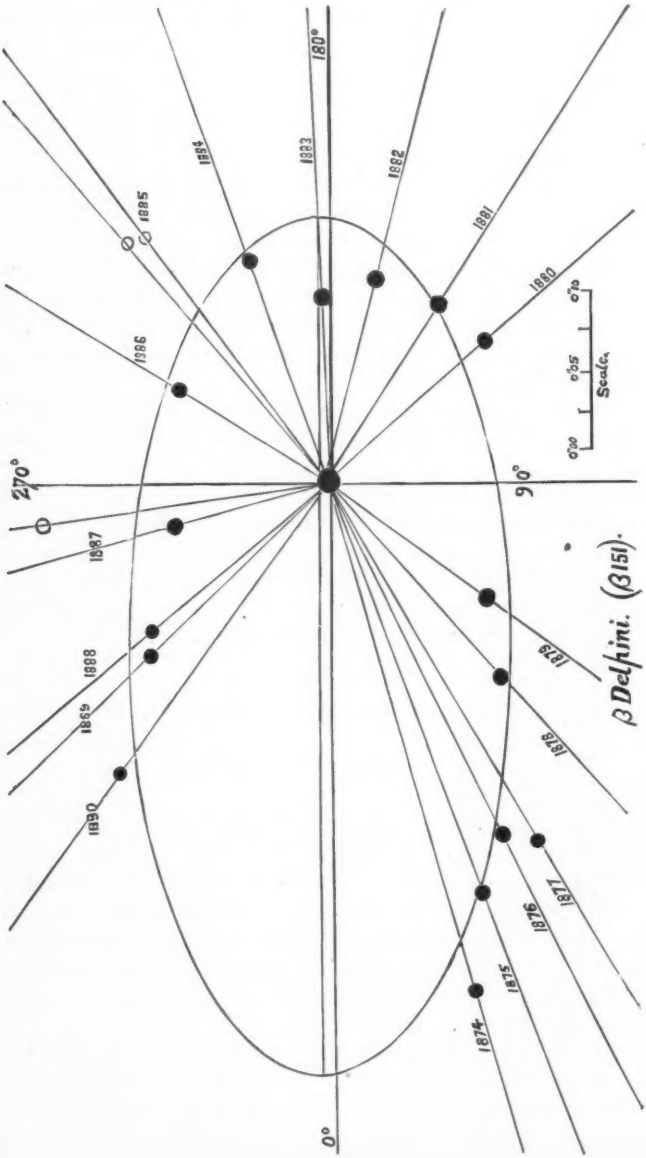
S. W. BURNHAM.*

FOR THE MESSENGER.

This pair has been under observation since 1873. The duplicity of the large star was discovered with the 6-inch telescope in August of that year, but the measures commence in 1874, and with the exception of 1879, when the distance was about minimum, it has been measured every year since. It was very soon apparent from the measures that this pair was in rapid motion, and likely to prove an interesting binary.

Three orbits have been computed for this pair; the first by Dubjago in 1884, who found a period of 26.07 years; the second by Gore in 1885 with a period of 30.91 years; and

*Astronomer at Lick Observatory.


180°
1884
1883
1882
1881
1880
1885
1886
1887
270°
90°
0°
Scale.
0".10
0".05
0".0
1888
1889
1890
1891
1878
1877
1876
1875
1874
β Delphini. (B151).

the third by Celoria in 1888 giving a period of 16.95 years. It is evident that the last period is considerably too short, as the time has already elapsed, and the companion has still some fifty degrees of position-angle to pass over to reach the place it occupied in 1874.

I have platted the best available measures, and after repeated trials, drawn an ellipse through these observed positions which would best represent them, and make the areas described substantially proportional. The observations are fairly accordant when the closeness and difficulty of the pair is considered, and the corrections necessary are comparatively small.

The ellipse shown gives a period of about 28½ years, and that certainly cannot be far from the actual time of rotation. The measures of the next few years will give additional data for a very accurate determination of the period; and during this time it will be easy to measure. The distance will not be less than 0″.6.

LICK OBSERVATORY, March 19.

IS IT PROBABLE THAT ANY PLANET OF THE SOLAR SYSTEM ROTATES ON ITS AXIS IN THE SAME TIME AS ITS PERIOD OF REVOLUTION AROUND THE SUN?

PROFESSOR GEORGE W. COAKLEY.*

FOR THE MESSENGER.

It is known that the moon rotates on her axis in the time in which she makes a sidereal revolution around the earth, and that the cause of this identity of the rotation and revolution periods is the elongation of the moon's diameter pointed towards the earth. This elongation is supposed to have been produced by the earth's attraction at the time when the moon was in a fluid condition, and is entirely similar to the tendency towards such an elongation produced by the tidal action of the moon and sun upon the waters of the earth.

Recently Professor Schiaparelli, the distinguished Italian astronomer has announced that the planets, Mercury and Venus, appear to rotate on their axes in their periods of rev-

* University of the City of New York.

olution around the sun. If this is the case it must be due to a tidal elongation of the diameters of these two planets towards the sun, produced by his attraction on their figures of equilibrium in the same way as the earth has acted on the moon.

To test the *probability* of such an action of the sun on the figures of equilibrium of these planets, the following approximate computations have been made with regard to the earth's tidal disturbing forces on the moon when in a fluid state, and of the similar tidal forces of the planets Jupiter, Saturn, Uranus and Neptune on their satellites, and then of the tidal forces of the sun on the earth and on Jupiter when they were fluid, and lastly of the tidal forces of the sun on the planets, Venus and Mercury, in a similar condition of fluidity.

An approximate computation of these several tidal forces will be sufficient for this purpose, as was ascertained by the more exact process employed in the paper, "On the Stability of the Rings of Saturn published in Nos. 80 and 81 of THE SIDEREAL MESSENGER. The numerical data for the several planets and satellites will be taken from the "Text-Book of General Astronomy," by Professor Charles A. Young, of Princeton College.

Let $a =$ the mean distance of a satellite from its primary planet, or the mean distance of a planet from the sun; and let $r =$ the radius of the satellite, or the radius of the planet. Also let $m =$ the mass of the planet attracting its satellite, or the mass of the sun attracting a planet. The masses will all be expressed in terms of the earth's mass, as the unit, and the radii and distances in miles. The unit of attractive force will then be the value of the acceleration that might be produced by the earth at one mile from its center, if the whole mass of the earth were concentrated at this center.

The attraction of a planet for its satellite, or of the sun for a planet, at its center, will be expressed by $\frac{m}{a^2}$.

At the nearest point of the satellite to its primary, or of a planet to the sun, the attraction will be $\frac{m}{(a-r)^2}$; and at the farthest point of the satellite, or planet, it will be $\frac{m}{(a+r)^2}$

Let f_1 = the difference of attraction on the nearest point, and on the center of the satellite or planet; and let f_2 = the difference of attraction on the center and on the farthest point of the satellite or planet. The disturbing force, f_1, tends to draw away the nearer portions of the satellite, or planet, from the center; and the force, f_2, tends to draw away the center from the farthest portions of these bodies; or, what is equivalent, the force, f_2 *acts as though* it REPELLED these remote portions from the center.

Regarding both these forces as positive quantities, it is evident that

$$f_1 = \frac{m}{(a-r)^2} - \frac{m}{a^2}, \quad f_2 = \frac{m}{a^2} - \frac{m}{(a+r)^2}.$$

Hence

$$f_1 = \frac{2mr}{a^3} \cdot \frac{1-\frac{1}{2}\cdot\frac{r}{a}}{(1-\frac{r}{a})^2}, \quad = f_2 \frac{2mr}{a^3} \cdot \frac{1+\frac{1}{2}\cdot\frac{r}{a}}{(1+\frac{r}{a})^2}.$$

Let $\beta = \frac{r}{a}$; then

$$f_1 = \frac{2m\beta}{a^2} \cdot \frac{1-\frac{1}{2}\beta}{(1-\beta)^2} = \frac{2m\beta}{a^3} \cdot (1 + \tfrac{3}{2}\beta + \tfrac{4}{2}\beta^2 + \tfrac{5}{2}\beta^3 + \text{etc.})$$

$$f_2 = \frac{2m\beta}{a^2} \cdot \frac{1+\frac{1}{2}\beta}{(1+\beta)^2} = \frac{2m\beta}{a^2} (1 - \tfrac{3}{2}\beta + \tfrac{4}{2}\beta^2 - \tfrac{5}{2}\beta^3 + \text{etc.})$$

The first power of β within the parentheses will be a sufficient approximation for the investigation proposed, as $\beta = \frac{r}{a}$ is always a small fraction. Hence the above formulæ may be written:

$$\left.\begin{aligned} f_1 &= \frac{2m\beta}{a^2}(1 + \tfrac{3}{2}\beta) \\ f_2 &= \frac{2m\beta}{a^2}(1 - \tfrac{3}{2}\beta) \end{aligned}\right\}, \qquad \text{(A)}.$$

The first inference from these formulæ is, that f_1 is always greater than f_2; or that the nearer portions of the satellites or planet are always *pulled forward* more than the remoter portions are *pushed back*. The center of gravity of the attracted body must therefore be transferrd to some point within the hemisphere nearest to the attracting body. The *transference of the centre of gravity* towards the attracting body, together with the *amount of elongation* of the

diameter towards the source of attraction, are the causes of the co-incidence of the periods of rotation and of revolution.

Let us now see how large these forces, f_1 and f_2, are in the case of a fluid moon attracted by the earth, and in the cases of the satellites of Jupiter, Saturn, Uranus and Neptune, and in the cases of the sun's attraction of the different planets.

In the case of the earth and our moon, $r = 1081$ miles = the moon's radius, and its mean distance, $a = 238{,}840$ miles, according to Professor Young. Taking the earth's mass as a unit, $2m = 2$.

$$\therefore r = [3.033826]$$
$$a = [5.378107]$$
$$\therefore \beta = [\bar{3}.655719] = 0.00452604, \quad \tfrac{3}{2}\beta = 0.00678906$$
$$2m = [0.301030]$$
$$1 - \tfrac{3}{2}\beta = [\bar{1}.997042]$$
$$2m\beta = [\ \bar{3}.956749]$$
$$a^3 = [10.756214]$$
$$\frac{2m\beta}{a^3} = [\bar{1}3.200535]$$
$$\frac{2m\beta}{a^3} = [\bar{1}3.200535]$$
$$f_2 = [\bar{1}3.197577]$$
$$1 + \tfrac{3}{2}\beta = [\ 0.002939]$$
$$f_1 = [\bar{1}3.203474]$$

$$\text{Hence } f_1 = \frac{0.159763}{10^{12}}$$
$$f_2 = \frac{0.157604}{10^{12}}$$
$$f_1 - f_2 = \frac{0.2159}{10^{14}}$$

f_1 and f_2 are, approximately, the measure of the earth's tidal disturbing forces on the moon's figure of equilibrium; and their difference, $f_1 - f_2$, is the excess of the earth's attraction on the nearer hemisphere over that on the remote hemisphere, and measures approximately the degree of transference of the moon's centre of gravity towards the earth. These forces, approximately, produce the elongation of the moon's diameters directed toward the earth, the displacement of its center of gravity, and thereby the co-incidence of its periods of rotation and revolution.

The same formulæ applied in like manner to Jupiter and his first satellite, with the data from Professor Young's Astronomy, $r = 1250$ miles, $a = 261000$ miles, $m = 316$, or $2m = 632$ times the earth's mass, give

$$f_1 = \frac{0.44750}{10^{10}}, \quad f_2 = \frac{0.44114}{10^{10}}, \text{ and } f_1 - f_2 = \frac{0.636}{10^{12}}$$

Hence it appears that in the action of Jupiter on his first satellite, his disturbing forces, f_1 and f_2, on its figure of equilibrium are more than 280 times those exerted by the earth on our moon, and the difference of his forces, for displacing the satellite's center of gravity, is more than 290 times the similar action of the earth on the moon.

If the earth's action on our moon, when it was fluid, was great enough to impress on our satellite a form that should cause its rotation and revolution periods to coincide, much more could Jupiter produce such an effect on his first satellite.

For Jupiter's second satellite Professor Young's data are $r = 1050$ miles, $a = 415000$ miles, $2m = 632$. Hence, by the same formulæ,

$$f_1 = \frac{0.93198}{10^{11}}, \quad f_2 = \frac{0.92600}{10^{11}}, \quad f_1 - f_2 = \frac{0.598}{10^{13}}$$

Here, also Jupiter's disturbing forces on his second satellite's figure of equilibrium are about 58 times as great as those exerted by the earth on our moon, and their difference is about 28 times that of the earth for displacing the center of gravity of this satellite. The second satellite of Jupiter ought, therefore, to have also a coincidence of its periods of rotation and revolution.

For the third satellite, the data are $r = 1775$ miles, $a = 664{,}000$ miles, $2m = 632$. Hence by the formulæ,

$$f_1 = \frac{0.38472}{10^{11}}, \quad f_2 = \frac{0.38165}{10^{11}}, \text{ and } f_1 - f_2 = \frac{0.307}{10^{13}}$$

Here the forces f_1 and f_2 are about twenty-four times those exerted by the earth, and their difference about fourteen times the corresponding difference in the case of the earth and moon. Hence Jupiter's third satellite should also rotate upon its axis and revolve around the planet in the same time.

For Jupiter's fourth satellite, $r = 1480$ miles, $a = 1117000$ miles, and $2m = 632$. Hence, by the formulæ,

$$f_1 = \frac{0.58965}{10^{12}}, \quad f_2 = \frac{0.58743}{10^{12}}, \text{ and } f_1 - f_2 = \frac{0.222}{10^{14}}$$

A glance at the corresponding values for the earth and moon shows that these values, f_1 and f_2, for Jupiter and his fourth satellite, are between three and four times as great, while the difference $f_1 - f_2$ is nearly the same, though a little larger than in the case of our moon. Hence all of Jupiter's satellites ought, for the same reason as our moon, to rotate on their axis in their several periods of revolution around him.

For Saturn's satellites, taking his mass $m = 94.9$ that of the earth, as given by Professor Young, and the other data from his Astronomy, the same formulæ give similar results for the first six satellites; the disturbing actions on their figures of equilibrium, and their differences being in each case larger than those of the earth's action on our moon. Hence the first six satellites should rotate in their periods of revolution about the planet. For the seventh satellite of Saturn the formulæ and data give the results,

$$f_1 = \frac{0.58260}{10^{13}}, \quad f_2 = \frac{0.58213}{10^{13}}, \text{ and } f_1 - f_2 = \frac{0.47}{10^{16}}$$

Hence the forces, f_1 and f_2, exerted by Saturn on his seventh satellite are more than one-third of those exerted by the earth, and their difference is about one-forty-sixth the corresponding difference in the case of the earth and moon.

For Saturn's eighth satellite, the results are

$$f_1 = \frac{0.15111}{10^{13}}, \quad f_2 = \frac{0.15092}{10^{13}}, \quad f_1 - f_2 = \frac{0.19}{10^{16}}$$

The values of f_1 and f_2 are about one-fifteenth of those exerted by the earth on our moon, and the difference, $f_1 - f_2$, is about one one-hundred and fourteenth of the corresponding difference for the earth and moon.

These two last satellites of Saturn must therefore be left in doubt whether they have such a figure of equilibrium impressed upon them as to cause a coincidence of their periods of rotation and revolution.

For the first satellite of Uranus, with the mass $2m = 29.4$ that of the earth, the formulæ and data give

$$f_1 = \frac{0.42668}{10^{11}}, \quad f_2 = \frac{0.42402}{10^{11}}, \quad f_1 - f_2 = \frac{0.266}{10^{13}}$$

The forces f_1 and f_2 are more than twenty-five times as great, and their difference more than twelve times that for the earth and moon.

The remaining three satellites of Uranus exhibit also a greater value of the forces f_1 and f_2 and also their difference, above those for the earth and moon. Hence it is probable that these satellites all rotate on their axes in their several periods of revolution around the planet.

The same law also holds good for the single known satellite of Neptune, since the computed values of f_1 and f_2 and $f_1 - f_2$ are larger than for the earth and moon. The satellites of Mars have not been examined because the values of their diameters can be considered as little better than mere guesses.

This investigation makes it highly probable that all the satellites of the solar system, if we except those of Mars, and the last two of Saturn, which are doubtful, rotate on their axes in the periods respectively of their revolutions about their primary planets.

If it be supposed that when the planets were in a fluid state, the sun may have impressed upon them an elongated form in his own direction, as the earth has done on the moon, it will be interesting to inquire what the forces f_1 and f_2 and their differences $f_1 - f_2$ would be in such cases, and to compare their values with those produced by the earth in disturbing the moon's figure of equilibrium. To consider first the case of the sun's action on the earth. According to Professor Young, the radius of the earth is $r = 3959$ miles, $a = 92900000$ miles = the earth's mean distance from the sun. The sun's mass compared with that of the earth as a unit, gives $2m = 662200$. Hence, by the formulæ (A),

$$f_1 = \frac{0.32701}{10^{14}}, \quad f_2 = \frac{0.32696}{10^{14}}, \quad f_1 - f_2 = \frac{0.5}{10^{18}}$$

These values of f_1 and f_2 are about the one-forty-eighth or one-forty-ninth part of those exerted by the earth on the moon, and their difference is less than one-four thousandth of of the corresponding difference for the moon. These results are very much smaller than the action of Saturn and his two most distant satellites. They may be regarded as the measure of the sun's impotence to produce such a change of the earth's figure of equilibrium as to compel a coincidence of the two periods of rotation and revolution. It is unnecessary to try the case of Mars and the sun, since r being less

and a being greater than in the earth's case, it is certain that f_1, f_2, and $f_1 - f_2$ will be less for Mars than for the earth. But since r is much larger for Jupiter than for any of the planets, it will be interesting to compare the disturbing forces of the sun on Jupiter's figure with those exerted on the earth and with those of the earth on the moon.

For Jupiter Professor Young gives $r = 86500$ miles, $a = 483300000$ miles. Hence, by the same formulæ,

$$f_1 = \frac{0.50754}{10^{15}},\ f_2 = \frac{0.50727}{10^{15}},\ f_1 - f_2 = \frac{0.27}{10^{18}}$$

These values are smaller than in the case of the sun's action on the earth. Hence it is not surprising that the earth and Jupiter do not obey the equality of the periods of rotation and revolution. It would be useless to test the cases of the planets beyond Jupiter, because r being less, and a being greater for these than for Jupiter, it is certain that the forces f_1 and f_2, and their difference, will be progressively less for these more distant planets.

For Venus, $r = 3850$ miles, $a = 67{,}200{,}000$ miles, according to Professor Young. Hence, by similar computations to those for the earth and Jupiter, it will be found that

$$f_1 = \frac{0.84019}{10^{14}},\ f_2 = \frac{0.84005}{10^{14}},\ f_1 - f_2 = \frac{1.4}{10^{18}}$$

The earth exerts on our moon values of f_1 and f_2, about 19 times as great as these of the sun on Venus; and the difference $f_1 - f_2$, in the case of the earth and moon is about 1500 times as great as the corresponding difference for the sun and Venus. These effects of the sun on Venus are, however, all of them between two and three times as great as those which the sun exerts on the earth. There is therefore, little probability that the sun's disturbing forces on the figure of equilibrium of Venus could cause the periods of rotation and of revolution of that planet to coincide.

For Mercury, Professor Young gives $r = 1515$ miles, $a = 36{,}000{,}000$. Hence by the same formulae

$$f_1 = \frac{0.21504}{10^{13}},\ f_2 = \frac{0.21501}{10^{13}},\ f_1 - f_2 = \frac{3}{10^{18}}.$$

Compared with the disturbing forces of the earth on the moon, those of the sun on Mercury are less than one-seventh

the values of the former, and the difference of the forces, $f_1 - f_2$, on Mercury, is less than one-seven-hundredth of that produced by the earth on the moon. But compared with the sun's action on the earth the f_1 and f_2 on Mercury are a little more than six and a half times those exerted by the sun on the earth. The difference, $f_1 - f_2$, of the sun's action on Mercury is also six times his action in this respect on the earth. It may be doubted perhaps whether the action of the sun on the planet Mercury would be sufficient to control his figure of equilibrium, and the position of his center of gravity, in such a manner as to cause his period of rotation to be identical with that of his revolution about the sun. The observations of the distinguished Italian astronomer are doubtless correct and valuable, but they may perhaps be susceptible of of a different interpretation.

AN ELEMENTARY METHOD FOR CALCULATING TRANSITS OF VENUS AND MERCURY.

MILTON UPDEGRAFF.*

FOR THE MESSENGER,

The convenient and accurate method of Lagrange for computing transits of Venus and Mercury is the one usually employed, and the results of its application to the coming transit of Mercury on May 9th are given on page 414 of the American Ephemeris, and also on pages 365-6 of the *Berliner Astronomisches Jahrbuch* for 1891. In each of these books are given the times of the contacts for the center of the earth and convenient formulæ for computing the times of contact for any place on the earth's surface. But the development of the general formulæ by Lagrange's method is a rather abstruse mathematical process, and it is the object of this paper to show a way of calculating transits of Venus and Mercury which may be understood by any student possessing a knowledge of elementary astronomy, plane trigonometry and algebra. This can best be done by applying the method to the transit of Mercury on May 9th of this year.

We have first to extract the necessary data from the daily

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ephemerides of the sun and Mercury given on page 75 and 222 of the American Ephemeris for 1891. The places of the sun and Mercury are given for Greenwich mean noon, and Greenwich time will be used in the computation. By a casual inspection of the right ascensions and declinations of the sun and the planet for May 7th, 8th and 9th, it will be seen that these bodies are moving in opposite directions and approaching each other in both co-ordinates. It is evident that they will be nearest together at some time on May 9th. We next determine with accuracy the time when the sun and Mercury are in conjunction in right ascension. To do this the following method will be employed which may be found in a less extended form in Loomis' Practical Astronomy, page 210.

The right ascensions of the sun and Mercury are taken out of the ephemeris for a few days before and after May 9th and set in adjacent columns as below:

Date 1891	R. A. of Mercury	R. A. of Sun	Sun — Mercury	1st Diff.	2nd Diff.	3d Diff.	4th Diff.
	h m s	h m s	m s	m s	s	s	s
May 7	3 12 23.48	2 56 35.76	+15 47.72				
				−5 51.88			
" 8	3 10 24.31	3 0 28.47	+ 9 55.84		−5.05		
				−5 56.93		+ 2.42	
" 9	3 8 20.66	3 4 21.75	+ 3 58.91		−2.63		+ 0.01
				−5 59.56	−1.415	+ 2.43	
" 10	3 6 14.95	3 8 15.60	− 2 0.65		−0.20		−0.09
				−5 59.76		+ 2.32	
" 11	3 4 9.61	3 12 10.02	− 8 0.41		+ 2.12		
				−5 57.64			
" 12	3 2 6.95	3 16 5.00	−13 58.05	*a*	*b*	*c*	*d*

The difference of right ascensions of the sun and Mercury are taken for each day and are set down in the fourth column. These differences of right ascension are equi-distant values of a function and we wish to determine at what time it is zero. We know that it must be zero at some time on May 9th, since on that day it passes from plus to minus. We now take the various orders of differences as for interpolation, but instead of desiring to find the value of the function for a certain time we wish to find at what time the function has a certain value. For this purpose we may use any of the algebraic formulæ for interpolation and will adopt Bessel's, which is

$$a_t = a_0 + tb + \frac{t(t-1)}{2}c + \frac{t(t-1)(t-\frac{1}{2})}{2.3}d, \text{ etc.}$$

Now $a_t = 0$, and neglecting all terms except the first two we have for a first approximation $t = -\frac{a_0}{b}$.

Neglecting only the last term we have as a second approximation $t = \frac{a_0}{b - \frac{c}{2} - \frac{c}{2} \cdot \frac{a_0}{b}}$, and making use of the last term $t = \frac{-a_0}{b - \frac{c}{2} + \frac{d}{12} + t\left\{\frac{c}{2} - \frac{d}{4}\right\} + t^2\frac{d}{6}}$

In using this last formula the value of t used in the denominator is the value given by the second approximation. The values of b, c and d are the differences between the horizontal lines in the table and $a_0 = +\ 3^m\ 58^s.91$.

By the third approximation the value of t is 0.664844 days $= 15^h\ 57^m\ 22^s.5$, which is the time of conjunction in right ascension on May 9th. The following data are interpolated from the Ephemeris for this time using 2d and 3d differences when necessary:

R. A. of sun and Mercury, $3h\ 6m\ 57.2s$		Hourly motions	$+\ 2'\ 26''.22, -\ 1'\ 18''.51$
Declination of Mercury	$+\ 17°\ 18'\ 0''.5$	Hourly motion	$-\ 1\ \ 6\ .68$
Declination of sun	$+\ 17\ \ 32\ \ 1\ .3$	Hourly motion	$+\ \ 39\ .53$
Eq. Hor. Parallax of sun	$8\ .75$	Semidiameter	$15\ \ 52\ .3$
Eq. Hor. Parallax of Mercury	$15\ .85$	Semidiameter	$6\ .0$

The difference of declination of Mercury and the sun at conjunction is $14'\ 0''.8$ which is less than the semi-diameter, and it is evident that there will be a transit of the planet across the sun's disk. It should also be remarked that the planet approaches the sun from the east and passes downward and westward across the disk.

By an application of the usual method for projecting eclipses of the moon it is possible, with the above data, to get the times of the contacts within two or three minutes. But we shall make use of this graphical process only for the purpose of illustration. Draw a horizontal line IJ (see Fig. 1) and a vertical line GK intersecting at right angles at C. Lay off IC to represent the semi-diameter of the sun, and with radius IC and center C draw the circle GIK to represent the sun's disk. Let GK be a portion of a

great circle of the celestial sphere passing through the sun's center from the pole to the equator. Then IJ will be a portion of a small circle parallel to the equator and passing through the sun's center at declination + 17° 32′ 1″.3. The hourly motion in declination of the sun is 39″.53 north, and that of Mercury is 1′ 6″.68 south. They therefore approach each other in declination with an hourly motion of 1′ 46″.21 on a great circle. Lay off mC* to represent 1′ 46″.21. The hourly motion in right ascension of the sun is 2′ 26″.22 east and that of Mercury is 1′ 18″.51 west.

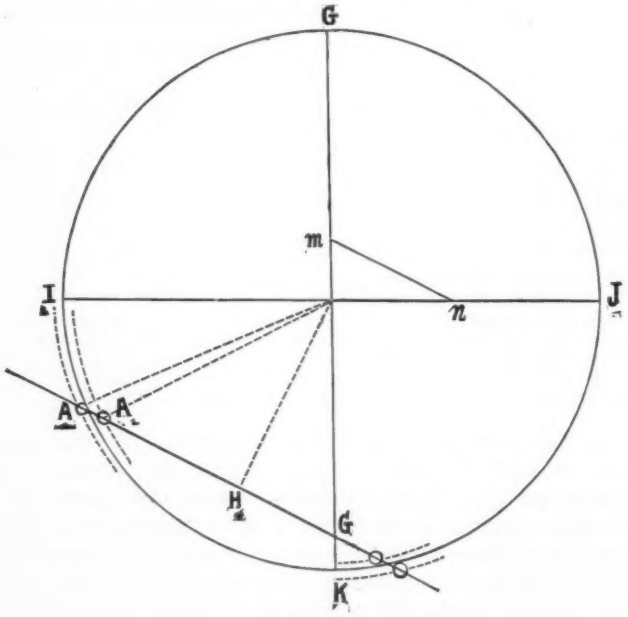


FIG. 1.

But these motions are on a small circle and being given in time, are larger than than they would be if given in angular space measured on a great circle, on the same principle that a star near the pole moves slower in its diurnal motion than a star near the equator. These motions vary as the secant of the declination, and we therefore divide the hourly

*C should be at the middle point of the cut. Omission was engraver's fault.

motions of the sun and Mercury in right ascension by the secants of their declinations, or what is the same thing, multiply them by the cosines.

(2′ 26″.22)cos 17° 32′ + (0′ 18″.51)cos 17° 18′ = 3′ 34″.39. Lay off *Cn* equal to 3′ 34″.39 on the same scale as *mC*. Then *mn* will be parallel to the path of the planet. At conjunction the planet will be at some point on *CK* and at a distance from *C* equal to the difference between its declination and that of the sun. This difference is 14′ 0″.8, Mercury being south. Lay off *CG* equal to 14′ 0″.8 on the same scale to which the semi-diameter of the sun is drawn. *G* is a point in the path of the planet and the line *AG* drawn parallel to *mn* is the path of the planet across the sun's disc as seen from the center of the earth. From *C* with radius 15′ 58″.3, the sum of the semi-diameters of the sun and Mercury, draw an arc of a circle cutting *AG* at the point *A*. Also from the same center describe a circle with radius 15′ 46″.3, the difference of the diameters, and cutting *AG* at A′. (This cannot be done to scale since Mercury is a mere speck on the sun). *A* and *A′* are the positions of the center of the planet at 1st and 2d contact, and describing from these points small circles tangent to the sun's limb we have a true representation of the 1st and 2d contacts as seen from the earth's center, except that Mercury is drawn on a much larger scale than the sun.

Draw the lines *CA*, *CA′* and *CH*. All the straight lines in the figure really represent arcs of great circles, but their curvature is so slight that the error due to its being neglected is far from being appreciable. The triangles formed by them may therefore be solved as plane triangles.

We now proceed to calculate the times of the 1st and 2d contacts as seen from the center of the earth. From the triangle *nCm* we get *nm* = 3′ 59″.257, angle *m* = 63° 38′ 45″.5 and angle *n* = 26° 21′ 14″.5. In the triangle *ACG* we have angle *AGC* equal to *nmC* since *AG* and *nm* are parallel. AC = 15′ 58″.3 = the sum of the diameters of the sun and Mercury, and *CG* = 14′ 0″.08 = the difference of their declinations at conjunction. Having three sides and an angle we compute *AG* = 16′ 5″.46, *CAG* = 51° 49, 54″.0 and *ACG* = 64° 31′ 20″.5. We also find *CH* = 12′ 33″.4 which is the nearest approach of Mercury to the

center of the sun. When at 1st contact the planet is at the distance *AG* from conjunction in right ascension, and dividing this distance, 16′ 5″.46, by 239″.257, the hourly motion in the line *AG*, we have $4^h.03525 = 4^h\ 2^m\ 6^s.9$, the time it will take the planet to pass from 1st contact to conjunction in right ascension. The time of conjunction being $15^h\ 57^m\ 22^s.5$, and subtracting $4^h\ 2^m\ 6^s.9$ we get $11^h\ 55^m\ 15^s.6$, which is the Greenwich time of 1st contact as seen from the center of the earth. In the same way, by solving the triangle *A′CG* we find the time of 2d contact to be $12^h\ 0^m\ 11^s.0$. Subtracting 6 hours from the Greenwich time of 1st and 2d contacts gives the central time of their occurrence as about 6 o'clock P. M. On May 9th the sun sets at ten minutes past seven o'clock at this latitude and since the 3d and 4th contacts occur more than four hours later than the 1st and 2d, the last two contacts will be invisible here and are not computed for this reason.

This computation is rigorous excepting that no account is taken of the small variations in the rapidity of motion of the sun and Mercury which take place between the times of the contacts and conjunction. But the chief uncertainty lies in the computation of the time of conjunction, which is due to the fact that the places of the sun and the planet are not known with perfect accuracy. There is some uncertainty also in the adopted semi-diameter of the sun, and according to the *Berliner Jahrbuch* a variation of one second of arc in the sun's semi-diameter affects the times of the contacts by 24 seconds of time.

In order to give an idea of the accuracy that may be expected of a prediction of a transit of Mercury, we give below the times of the 1st and 2d contact as given in the American Ephemeris and the *Berliner Jahrbuch*. Different tables of Mercury are used at Washington and Berlin, but both are based on the researches of the celebrated French astronomer, *Le Verrier*.

	Geocentric 1st. Contact	Geocentric 2d Contact.
Am. Ephemeris	$11^h\ 55^m\ 29^s.3$	$12^h\ 0^m\ 25^s.0$
Berliner Jahrbuch	11 54 13	11 59 9

For any place on the surface of the earth at which the sun and Mercury are in the zenith at the time of a contact that contact will be seen at the same time as from the center of

the earth. But for all other places on the earth the contact will take place sooner or later on account of the effect of parallax. We now proceed to compute the corrections for parallax at the 1st and 2d contacts as seen from Columbia, Missouri.

Interpolating the declination of Mercury for the Greenwich time of 1st contact as seen from the earth's center, and subtracting our longitude, $6^h\ 9^m\ 18^s$, from the same time we have $+\ 17°\ 22'$ for the declination of the planet and $5^h\ 45^m\ 58^s$ for the local mean time of geocentric 1st contact. Adding to the latter the equation of time, $3^m\ 41^s$ (see p. 75 Am. Eph.), we have $5^h\ 49^m\ 39^s$ as the west hour angle of the sun at geocentric 1st contact, which diminished by 1^m, the semidiameter of the sun in time, gives very nearly, as the hour angle of the planet $5^h\ 48^m\ 39^s$. From the declination and hour angle the difference of parallax of the sun and Mercury in both right ascension and declinatian are comput ed by the usual formulæ for the purpose, which may be found in *Chauvenet's Sphr. and Pract. Ast., Vol. 1, p. 125.* This might be worked out independently by a simple application of the principles of spherical trigonometry but it would be rather tedious and it will be best to compute these small corrections by means of the formulæ above referred to, and the results only are given here. The difference of parallax in right ascension is $5''.80$ and in declination $4''.20$.

Since Columbia is north of the plane of the equator an observer here will see both the sun and Mercury projected lower down towards the celestial equator on the celestial sphere than he would if situated at the center of the earth. Mercury being nearer the earth will be more depressed than the sun, and since he is below the sun's center the effect of difference of parallax in declination at Columbia will be to depress Mercury still farther below the center of the sun. Again, conceive a plane passing through the earth's axis and the center of the sun. Since Columbia is above this plane Mercury and the sun will be depressed toward it, Mercury more than the sun, as before. But since the planet is now above the sun's center, the effect of difference of parallax in right ascension will be to throw it nearer to the sun's center. In Fig. 2, let *BF* be a portion of the sun's limb (on an enlarged scale) at the point of 1st contact, and

let *a* be the place of the planet at 1st contact as seen from the earth's center (*A* in Fig. 1). Draw a vertical line *ax* to represent the effect of difference of parallax in declination (4″.20) and a horizontal line *xc* for the effect of difference of parallax in right ascension (5″.80). When the planet is seen at *a* by an observer at the earth's center it is seen on the sun's disk at *c* by an observer at Columbia, and 1st contact occurs sooner at Columbia than at the center of the earth.

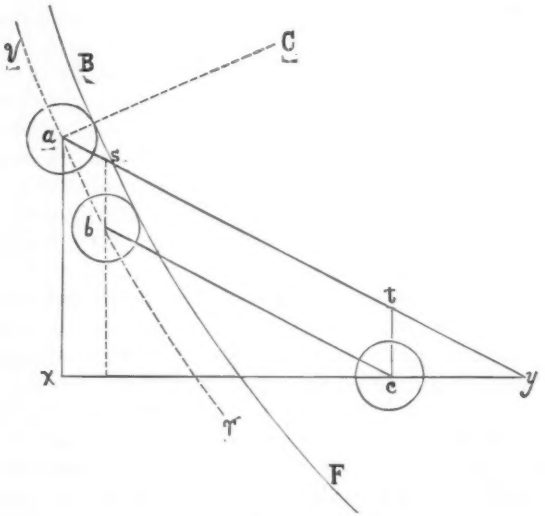


FIG. 2.

Parallax in declination depresses the planet from *a* to *x*, and parallax in right ascension shifts it from *x* to *c*. From *a* draw *aC* in the direction of the sun's center, and also *ay*, making the angle *Cay* equal to $CAG = 51° 49' 54''.0$ in Fig. 1. From the sun's center, with radius equal to the sum of the diameters of the sun, and the planet, describe the arc *qr*. Of course it will pass through *a* and all other portions of the center of the planet at exterior contact. *ay* is a portion of the path of the planet as seen from the earth's center, and *bc* drawn through *c* parallel to *ay* and cutting *qr* in *b* is a part of the path of the planet as seen from Columbia. *b* is the position of the planet as seen from Columbia. Produce *xc*

to y and draw ct and sb parallel to ax. First contact takes place at Columbia earlier than it does at the center of the earth by the time it takes the planet to move from b to c. If the distance bc is known, this time may be found by dividing bc by the hourly motion of the planet. Triangle axy is similar to mCn in Fig. 1 since the sides are parallel each to each. Angle $xay = 63^\circ\ 38'\ 45''$ and the side $ax = 4''.20$ and we find $xy = 8''.46$ and $ay = 9''.44$. $ax - xc = 8''.46 - 5''.80 = 2''.66 = cy$, and from the triangle tcy we have $tc = 1''.32$ and $ty = 2.97$. In the small triangle asb, $sb = tc = 1''.32$, angle $s = 180^\circ - yax$ and angle $sab = 90^\circ - Cay = 90^\circ - 51^\circ\ 49'\ 54''$, and solving it we get $bs = 0''.91$. From ay subtracting as and ty we have $9''.44 - 0''.91 - 2''.97 = 5''.56 = st = bc$ $5''.56 \div 239''.26$ (the hourly motion) $= 0.02324$ hours $= 1^m\ 23^s.7$. An observer at Columbia sees 1st contact $1^m\ 23^s.7$ sooner than an observer at the center of the earth, and subtracting this correction for parallax from $11^h\ 55^m\ 15^s.6$ we get $11^h\ 53^m\ 51^s.9$, which is the Greenwich mean time of 1st contact as seen at Columbia. In the same way the correction due to parallax for 2d contact is computed and found to be $1^h\ 22^s.8$, and, when subtracted $12^h\ 0^m\ 11^s.0$, the time of 2d contact for the earth's center, gives $11^h\ 58^m\ 48^s.2$ as the Greenwich mean time of 2d contact for Columbia. Subtracting 6 hours from the Greenwich time gives as the central times of 1st and 2d contacts at Columbia, Missouri, according to this computation,

1st Contact, $5^h\ 53^m\ 51^s.9$, 2d Contact, $5^h\ 58^m\ 48^s.2$.

In Fig. 1, the angle $ACK = 64^\circ\ 31'$, is the angular distance from the south point of the sun at which 1st contact takes place. Or, the supplement of ACK, $GCA = 115^\circ\ 29'$, is the angular distance of 1st contact from the north point reckoned to the left.

OBSERVATORY OF THE STATE UNIVERSITY OF MISSOURI.

April 6, 1891.

METEOR RADIANTS.

W. F. DENNING, ENGLAND.

FOR THE MESSENGER.

Mr. Monck, in his letter to THE SIDEREAL MESSENGER of February, p. 109, assumes an air of injured innocence. But he is still inaccurate in certain statements, and I am sorry there is a further necessity for me to reply to your irrepressible correspondent.

He says my argument is that because he is not himself an observer he has no right to form any theory about meteors. I need hardly say this is quite inconsistent with fact. Your correspondent may theorise to his heart's content and without fear of hostile criticism from me. But he is not content to frame theories on the basis of observation; he first endeavors to subvert the observations and puts an entirely wrong construction upon them. It is this I object to.

Mr. Monck quotes his friend Mr. Gore, who, however, gives no support to his case. Mr. Gore follows a perfectly just and legitimate method in accepting observations and making computations from them, without thinking it desirable to overturn the data gathered by able and reliable men like Burnham. Suppose for a moment that Mr. Gore attempted to alter their facts and opposed the direct issues of their observations, I think it is very likely they would strongly resent such treatment. But Mr. Gore, far from assuming to dictate in such a way has a very keen appreciation of the observations, accepting them as they stand, and reducing them with honor to himself and those who made them.

If Mr. Monck will endeavor to theorise from my observations without going beyond his depth in futile efforts to overturn them, I shall be really much obliged to him, and I will give him any explanations that may be likely to help him. But when he attempts to group the radiants in an erroneous way, and derives false conclusions, it at once becomes necessary I should tell him he is not justified by experience to meddle with them in such a manner.

In his letter he remarks, "No decided case of shifting in a radiant has been established." A definite statement of this

kind, emanating from a man who has never yet observed the radiant point of a single meteor shower, and which is in direct contradiction to the evidences of modern observation, is simply worthless. I must confess to a feeling of surprise at the temerity (I had almost said assumption) which prompted it to be uttered.

Let Mr. Monck watch the sky in July and August next, and if he has any ability and patience as an observer he will see the shifting radiant of the Perseids for himself and cease this useless cavilling.

BRISTOL, Feb. 17, 1891.

[The above article was received too late for the March MESSENGER. It should have appeared in the April issue. By mistake it was omitted.—ED.]

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

The most noteworthy astronomical event to be predicted for this month is the *Transit of Mercury* across the suns's disk which will occur on May 9. Mercury passing between us and the sun will appear as a small, round, black spot, invisible without the aid of the telescope, moving very slowly across the solar disk. The transit will begin at about $5^h\ 54^m$ P. M. and will end at $10^h\ 53^m$ P. M., central time. Only the beginning will be visible in the United States, and in the eastern states the sun will then be so near the horizon that satisfactory observations will be impossible.

In our last number we gave a cut showing the paths of Mercury across the sun's disk during each transit of the present century, and also the exact times of the beginning of this transit at several of the observatories. The times of beginning of transit we will repeat for the sake of those who may not have received the last number of the MESSENGER, and call attention to the article by Professor Updegraff (See page 225).

Observatory.	External Ingress.	Standard of Time.
Harvard College,	$6^h\ 54^m\ 32.55^s$	Eastern.
New York City,	6 54 25.81	"
Washington,	6 54 18.64	"
Chicago,	5 54 19.73	Central.
Carleton College,	5 54 26.68	"
Lick,	3 54 17.99	Pacific.

The best way for those who have small telescopes to observe the transit will probably be to arrange the telescope so as to project the image of the sun upon a screen of white paper a foot or two back of the eye-piece. A

large shade should be placed on the tube of the telescope near the object end, to cut off from the screen the direct rays of the sun. By properly adjusting the focus a sharp image from four to eight or more inches in diameter can be obtained with a telescope of only an inch and a half aperture. The image of Mercury on the sun should be perfectly round and black, having a diameter about one one-hundred-and-fiftieth of that of the sun. It will enter upon the disk of the sun about 25° south of the east point.

The observations which an amateur may make will be to note the exact times when Mercury seems to touch the edge of the sun from the outside, then on the inside of the disk. These times will, however, be of no value, unless the error of the time-piece used, and the longitude and latitude of the place of observation are accurately determined. It will be well also to watch closely to see if a bright ring can be seen around that part of Mercury's disk which is off the solar disk, between first and second contacts. Also notice carefully whether there is any trace of a dusky fringe around the planet when wholly within the disk of the sun.

Venus may be seen in the east an hour before sunrise but is not in a favorable position for observation except during the day. Venus will be in conjunction with the moon, 2° 54′ north, on the morning of May 5, and again on June 4, 0° 12′ north. On the latter occasion Venus will be occulted as seen by observers in latitudes betwen 30° north and 45° south.

Mars may still be seen in the west each evening until nine o'clock, but is not in position to be well observed.

Jupiter may be observed after three o'clock in the morning. He is among the faint stars in Aquarius, seen towards the east in the morning.

Saturn will be at quadrature with the Sun, May 31. It is past the best time for observation this year, yet the phenomena attendant upon the changes in position of the rings should be watched very closely as long as it is possible to follow the planet. Good observations may sometimes be made before sunset.

Uranus may be best observed from 8 P. M. to 2 A. M. For its position among the stars see diagram February number of THE MESSENGER (page 142). It will be in conjunction with the moon, south 2° 54′, May 20 at 6 P. M.

Neptune will be at conjunction with the sun May 27, and so it is out of our view for the month.

MERCURY.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
May 25.....	2 52.2	+ 12 46	3 45 A. M.	10 40.2 A. M.	5 35 P. M.
June 5.....	3 17.8	+ 14 32	3 20 "	10 22.6 "	5 25 "
15.....	4 06.2	+ 18 31	3 11 "	10 31.4 "	5 52 "
25.....	5 18.5	+ 22 41	3 24 "	11 04.4 "	6 45 "

VENUS.

May 25.....	2 08.0	+ 11 03	3 09 A. M.	9 56.7 A. M.	4 44 P. M.
June 5.....	2 59.3	+ 15 21	2 58 "	10 04.2 "	5 10 "
15.....	3 47.8	+ 18 38	2 52 "	10 13.2 "	5 34 "
25.....	4 38.2	+ 21 09	2 51 "	10 24.1 "	5 57 "

MARS.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
May 25.....	5 34.1	+ 24 11	5 33 A. M.	1 21.8 P. M.	9 11 P. M.
June 5.....	6 06.0	+ 24 23	5 21 "	1 10.4 "	9 00 "
15.....	6 34.9	+ 24 12	5 11 "	12 59.9 "	8 49 "
25.....	7 03.4	+ 23 41	5 03 "	12 49.0 "	8 35 "

JUPITER.

May 25.....	23 07.0	− 6 48	1 19 A. M.	6 55.8 A. M.	0 32 P. M.
June 5.....	23 11.6	− 6 23	0 39 "	6 17.0 "	11 55 A. M.
15.....	23 14.8	− 6 06	0 02 "	5 40.9 "	11 20 "
25.....	23 16.9	− 5 56	11 24 P. M.	5 03.6 "	10 44 "

SATURN.

May 25.....	10 51.1	+ 9 32	11 56 A. M.	6 37.9 P. M.	1 19 A. M.
June 5.....	10 52.3	+ 9 23	11 15 "	5 55.9 "	0 37 "
15.....	10 54.1	+ 9 10	10 38 "	5 18.3 "	11 58 P. M.
25.....	10 56.4	+ 8 54	10 02 "	4 41.3 "	11 20 "

URANUS.

May 25	13 44.7	− 10 14	4 08 P. M.	9 31.0 P. M.	2 54 A. M.
June 5.....	13 43.5	− 10 08	3 24 "	8 46.6 "	2 10 "
15.....	13 42.7	− 10 04	2 43 "	8 06.5 "	1 30 "
25.....	13 42.3	− 10 02	2 03 "	7 26.6 "	0 50 "

NEPTUNE.

May 25.....	4 19.3	+ 19 52	4 40 A. M.	12 07.2 P. M.	7 34 P. M.
June 5.....	4 21.0	+ 19 56	3 58 "	11 25.7 A. M.	6 53 "
15.....	4 22.5	+ 20 00	3 20 "	10 47.9 "	6 15 "
25.....	4 24.0	+ 20 03	2 42 "	10 10.0 "	5 38 "

VESTA.

Apr. 24.....	18 30.2	− 17 58	11 30 P. M.	4 19 A. M.	9 08 A. M
May 18.....	18 34.6	− 18 28	10 00 "	2 48 "	7 36 "
June 11.....	18 20.3	− 19 48	8 18 "	12 59 "	5 40 "

PALLAS.

May 30.....	20 19.6	+ 18 02	8 28 P. M.	3 46 A. M.	11 04 A. M
June 23.....	20 10.4	+ 19 33	6 37 "	2 02 "	9 27 "

THE SUN.

May 25.....	4 08.9	+ 21 00	4 23 A. M.	11 56.7 A. M.	7 30 P. M.
June 5.....	4 53.8	+ 22 35	4 17 "	11 58.3 "	7 40 "
15.....	5 35.2	+ 23 20	4 15 "	12 00.2 P. M.	7 45 "
25.....	6 16.7	+ 23 24	4 17 "	12 02.4 "	7 48 "

THE MOON.

May 20.....	13 53.4	− 8 19	4 18 P. M.	9 59.4 P. M.	3 32 A. M.
21.....	14 41.7	− 13 33	5 24 "	10 43.6 "	3 55 "
22.....	15 33.2	− 18 14	6 32 "	11 31.0 "	4 23 "
23.....	16 28.7	− 22 08	7 43 "	12 22.4 A. M.	4 51 "
24.....	17 28.1	− 24 50	8 54 "	1 17.7 "	5 40 "
25.....	18 30.9	− 26 02	10 00 "	2 16.1 "	6 34 "
26.....	19 34.3	− 25 31	10 58 "	3 15.7 "	7 38 "
27.....	20 37.3	− 23 18	11 46 "	4 14.6 "	8 49 "
29.....	21 38.0	− 19 32	12 25 "	5 11.2 "	10 07 "
30.....	22 35.7	− 14 33	12 57 "	6 04.8 "	11 24 "
31.....	23 30.8	− 8 43	1 24 "	6 55.8 "	12 40 P. M.
June 1.....	0 24.2	− 2 24	1 48 "	7 45.1 "	1 50 "
2.....	1 16.9	+ 4 01	2 11 "	8 33.8 "	3 11 "
3.....	2 10.3	+ 10 13	2 35 "	0 23.0 "	4 27 "
4.....	3 05.3	+ 15 48	3 00 "	10 12.0 "	5 42 "
5.....	4 02.4	+ 20 26	3 30 "	11 07.0 "	6 57 "

THE MOON.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
June 6.....	5 01.5	+ 23 48	4 05 P. M.	12 02.0 P. M.	8 09 P. M.
7.....	6 01.7	+ 25 41	4 49 "	12 58.2 "	9 13 "
8.....	7 01.6	+ 26 00	5 40 "	1 53.9 "	10 07 "
9.....	7 59.5	+ 24 50	6 39 "	2 47.7 "	10 51 "
10.....	8 54.3	+ 22 23	7 42 "	3 38.5 "	11 26 "
11.....	9 45.8	+ 18 55	8 47 "	4 25.9 "	11 54 "
12.....	10 34.1	+ 14 41	9 51 "	5 10.1 "	12 18 A. M.
13	11 20.1	+ 9 54	10 55 "	5 52.0 "	12 39 "
14.....	12 04.6	+ 4 44	11 57 "	6 32.5 "	12 57 "
15.....	12 48.8	− 0 38	12 59 "	7 12.6 "	1 16 "
16.....	13 33.6	− 6 03	2 02 "	7 53.5 "	1 35 "
17.....	14 20.5	− 11 20	3 07 "	8 36.2 "	1 56 "
18.....	15 10.3	− 16 17	4 14 "	9 22.0 "	2 22 "
19.....	16 04.1	− 20 34	5 24 "	10 11.8 "	2 53 "
20.....	17 02.4	− 23 51	6 35 "	11 05.9 "	3 32 "
21.....	18 04.8	− 25 44	7 45 "	12 04.2 A. M.	4 22 "
22.....	19 09.7	− 25 54	8 48 "	1 05.0 "	5 24 "
23.....	20 14.8	− 24 15	9 42 "	2 06.0 "	6 37 "
24.....	21 17.9	− 20 54	10 25 "	3 05.0 "	7 54 "
25.....	22 17.8	− 16 10	11 00 "	4 00.8 "	9 13 "
26.....	23 14.3	− 10 29	11 29 "	4 53.2 "	10 30 "
27.....	0 08.2	− 4 15	11 53 "	5 43.0 "	11 46 "
29.....	1 01.8	+ 2 09	12 16 A. M.	6 31.5 "	1 00 P. M.
30.....	1 53.1	+ 8 22	12 39 "	7 19.8 "	2 15 "

Jupiter's Satellites.

	Central Time. h m		
May 16	2 00 A. M.	II Ec. Dis.	
18	12 40 "	IV Oc. Dis.	
18	1 41 "	II Tr. Eg.	
18	4 57 "	IV Oc. Re.	
19	1 26 "	III Sh. Eg.	
19	2 27 "	I Ec. Dis.	
19	3 14 "	III Tr. In.	
20	1 05 "	I Tr. In.	
20	2 05 "	I Sh. Eg.	
20	3 24 "	I Tr. Eg.	
25	1 27 "	II Tr. In.	
25	1 40 "	II Sh. Eg.	
26	1 49 "	III Sh. In.	
26	3 21 "	IV Sh. Eg.	
27	1 39 "	I Sh. In.	
27	3 01 "	I Tr. In.	
27	3 59 "	I Sh. Eg.	
27	5 20 "	I Tr. Eg.	
30	12 48 "	III Oc. Re.	
June 1	1 21 "	II Sh. In.	
1	4 06 "	II Tr. In.	
1	4 16 "	II Sh. Eg.	
3	2 04 "	II Oc. Re.	
4	12 44 "	I Ec. Dis.	
4	4 23 "	I Oc. Re.	
5	12 20 "	I Sh. Eg.	
5	1 43 "	I Tr. Eg.	
6	1 25 "	III Oc. Dis.	
6	4 51 "	III Oc. Re.	

	Central Time. h m		
June 8	3 58 "	II Sh. In.	
11	2 38 "	I Ec. Dis.	
11	11 55 P. M.	I Sh. In.	
12	1 18 A. M.	I Tr. In.	
12	2 14 "	I Sh. Eg.	
12	3 36 "	I Tr. Eg.	
12	11 49 P. M.	III Ec. Dis.	
13	12 46 A. M.	I Oc. Re.	
13	3 14 "	III Ec. Re.	
17	1 38 "	II Ec. Dis.	
19	1 28 "	II Tr. Eg.	
19	1 49 "	I Sh. In.	
19	3 11 "	I Tr. In.	
20	12 39 "	IV Ec. Dis.	
20	2 39 "	I Oc. Re.	
20	3 50 "	III Ec. Dis.	
20	11 57 P. M.	I Tr. Eg.	
24	2 44 A. M.	III Tr. Eg.	
26	1 09 "	II Tr. In.	
26	1 24 "	II Sh. Eg.	
27	12 54 "	I Ec. Dis.	
27	4 30 "	I Oc. Re.	
28	12 30 "	I Sh. Eg.	
28	1 49 "	I Tr. Eg.	
28	11 42 P. M.	IV Tr. In.	
29	3 26 A. M.	IV Tr. Eg.	
July 1	1 25 "	III Sh. Eg.	
1	3 11 "	III Tr. Eg.	

XUM

Configuration of Jupiter's Satellites at 3 a. m.

May 17	4 1 ○ 2 3	June 1	4 ○ 2 1 3
18	● 2 ○ 1 3	2	4 2 1 ○ 3
19	2 1 ○ 3 4	3	4 3 ○ 1 ●
20	3 ○ 2 4 𝔘	4	● 3 ○ 4 2
21	3 ○ 1 2 4	5	3 2 1 ○ 4
22	2 3 1 ○ 4	6	2 3 ○ 1 4
23	2 ○ 3 1 4	7	1 ○ 2 3 4
24	1 ○ 2 3 4	8	○ 2 1 3 4
25	𝔘 ○ 1 3 4	9	2 1 ○ 3 4
26	2 1 ○ 3 4	10	3 2 ○ 1 4
27	3 4 ○ 1 2	11	3 1 ○ 2 4
28	3 4 ○ 2 ●	12	3 2 ○ 1 4
29	4 3 2 1 ○	13	2 4 3 ○ 1
30	4 2 ○ 3 1	14	4 1 ○ 2 3
31	4 1 ○ 2 3	15	4 ○ 1 2 3

June 16	4 2 1 ○ 3
17	4 2 3 ○ 1
18	4 3 1 ○ 2
19	𝔘 4 3 ○ 1
20	2 4 3 ○ ●
21	1 ○ 4 2 3
22	○ 1 2 4 3
23	2 1 ○ 3 4
24	𝔘 2 ○ 1 4
25	3 1 ○ 2 4
26	3 ○ 2 1 4
27	2 3 1 ○ 4
28	𝔘 ○ 2 3 4
29	𝔘 ○ 1 2 3
30	4 2 1 ○ 3
July 1	4 2 ○ 3 1

The arrangement of the figures 1 2 3 4 indicates the positions of the four satellites relatlve to the planet ○. The sign 𝔘 signifies that the satellite whose number is missing is upon the face of the planet; ● signifies that the satellite is behind or in the shadow of the planet.

Minima of Variable Stars of the Algol Type.

[The times are given, to the nearest hour of Central Time, of only those minima which can be observed in the United States.]

U CEPHEI.

R. A.....0h 52m 32s
Decl.....+81° 17′
Period.....2d 11h 50m

May 26	5 A. M.
31	5 "
June 5	4 "
10	4 "
15	4 "
20	3 "
25	3 "
30	3 "

S CANCRI.

R. A.....8h 37m 39s
Decl.....+ 19° 26′
Period.....9d 11h 38m

May 17	5 A. M.
June 5	5 "
23	4 "

δ LIBRÆ.

R.A.....14h 55m 06s
Decl.....— 8° 05′
Period.....2d 07h 51m

May 16	8 P. M.
19	4 A. M.
23	8 P. M.
26	4 A. M.
June 2	3 "
9	3 "
16	2 "
23	2 "
30	2 "

U CORONÆ.

R. A.....15h 13m 43s
Decl.....+32° 03′
Period.....3d 10h 51m

May 17	5 A. M.
24	3 "
31	1 "
June 6	11 P. M.
13	8 "
24	5 A. M.

U OPHIUCHI.

R. A.....17h 10m 56s
Decl.....+ 1° 20′
Period.....0d 20h 08m

May 18	1 A. M.
18	9 P. M.
23	2 A. M.
23	10 P. M.
28	3 A. M.
28	11 P. M.
June 2	4 A. M.
2	midn.
3	8 P. M.
8	1 A. M.
8	9 P. M.
13	1 A. M.
13	9 P. M.
18	2 A. M.
18	10 P. M.
23	3 A. M.
23	11 P. M.
28	4 A. M.
28	midn.

Y CYGNI.

R.A.....20h 47m 40s
Decl.....+ 34° 15′
Period.....1d 11h 57m

May 17	5 A. M.
20	4 "
23	4 "
26	4 "
29	4 "
June 1	4 "
4	4 "
7	4 "
10	4 "
13	4 "
16	4 "
19	4 "
22	4 "
25	3 "
28	3 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N.P't. °	Duration. h m.
May 15...	η Leonis	3.3	3 58	143	* 5 14.9	265	1 17
15...	42 Leonis*	6.0	13 42	114	14 33.9	291	0 52
17...	ν Virginis	4.0	10 34	57	11 10.1	4	0 36
22...	41 Libræ	5.9	12 00	92	13 18.1	319	1 18
22...	κ Libræ	5.1	14 09	104	15 25.9	291	1 17
June 1...	33 Ceti	6.1	14 37	353	14 51.3	318	0 15
1...	35 Ceti	6.3	15 05	52	16 03.1	252	0 58

* Whole occultation below the horizon of Washington.

Phases and Aspects of the Moon.

			Central Time. d	h	m	
First Quarter	1891	May	15	1	04	P. M.
Apogee	"	"	16	10	54	"
Full Moon	"	"	23	12	26	"
Last Quarter	"	"	30	12	54	"
Perigee	"	"	31	3	06	"
New Moon	"	June	6	10	26	A. M.
Apogee	"	"	13	6	00	P. M.
First Quarter	"	"	14	6	34	A. M.

New Minor Planets.

A planet was discovered by Borelly of Marseilles, March 31.4436 Gr. M. T. $\alpha = 12^h\ 24^m\ 49^s.3$; $\delta = -1°\ 55'\ 32''$. Daily motion -40^s in α, and 5′ northward. Magnitude not given. This is apparently No. 309.

Another planet was discovered by Palisa at Vienna April 6.399 Gr. M. T., in right ascension $12^h\ 41^m$, and in declination $-6°\ 15'$. Daily motion is 14′ westward and 4′ northward. Magnitude 13th. The telegram was in error, so that a more complete statement of position or date of discovery of the planet can not be given. Probably No. 310.

Names have been given to asteroids as follows: 283, Emma; 284, Amelia; 285, Regina; 289, Nenetta; 290, Bruna; 291, Alice; 292, Ludovica; 293, Brasilia; 294, Felicia; 295, Theresia; 296, Phaëtusa; 297, Cecilia; 298, Baptisina; 300, Geraldina; 302, Clarissa.

New Planetary Nebula. (*DM.—12° 1172 magn. 9.2*). [Communicated by Edward C. Pickering, Director of Harvard College Observatory.] The photographic spectrum of DM—12° 1172 magnitude 9.2, whose approximate position for 1900 is in R. A. $5^h\ 22.9^m$, Dec. — 12° 46′, was obtained at this Observatory with the 8-inch Draper telescope on March 26, 1891, and proves to be that of a planetary nebula. Confirmation of this was obtained photographically on March 30, and also visually with the 15-inch equatorial telescope. As the hydrogen line F in this object is unusually strong as compared with the line whose wave-length is 500, the visual spectrum differs in a marked manner from that of the planetary nebulæ already known. M. Fleming.

Harvard College Observatory, Cambridge, Mass., April 14, 1891.

COMET NOTES.

Comet a 1891 (Barnard, March 29). The first comet of this year was discovered by E. E. Barnard at Lick Observatory, March 29.695 Gr. M. T. in R. A. $1^h\ 00^m\ 08^s$; Decl. north 44° 18′. Daily motion in declination 1° south. The head of the comet was about 1′ in diameter, the nucleus of the tenth magnitude, tolerably well defined, and the tail less than 30′ long. In a private letter dated April 12, Mr. Barnard says: "My comet of March 29 has been hidden by the clouds since the third of April and it will now be too near the sun to observe, even if it should clear again this spring. I only succeeded in getting six nights observations of it. It is scarcely probable that it will be visible after perihelion."

We have as yet (April 21) received no ephemeris of this comet. Mr. Wendell wrote April 16 that he had an orbit of the new comet partly finished, but learned that there was an error in one of the observations which he was using, so that it was necessary to do the work over again.

Winnecke's Periodic Comet. From a private letter we learn that Mr. Barnard has looked for Winnecke's comet with the great Lick telescope, but failed to find it. He says that it is either excessively faint or is not within 50^s in R. A., or 6′ in Decl. of Dr. Von Haerdtl's ephemeris position.

Discovery of a new Comet. On Monday evening, March 30 at 9 P. M., while comet-seeking with my 10-inch reflector, power 40, I alighted upon a nebulous object in Andromeda which I failed to identify. Being acquainted with the conspicuous nebulæ in this region I immediately suspected it to be a comet, and a few minutes sufficed to reveal motion. I then sent a telegraphic notification of the discovery to the Astronomer Royal at Greenwich, and the following morning, March 31, he wired to Professor Krueger at Kiel. I observed the new comet on March 30 at $16^h\ 30^m$, and on March 31 and April 4 at $8^h\ 30^m$. The motion of the comet is carrying it rapidly to the S.S.E., and it will disappear with the sun's rays in a short time. Towards the end of April the comet will be close to the sun in Aries.

On April 4 the sky was very clear, and the comet was seen to have a delicate, tapering tail. The nucleus and coma were decidedly brighter than on the occasion of my first observation on March 30. W. F. DENNING.

Comet Wolf 1884. Mr. Berberich of the Berlin Observatory, has communicated to Mr. Barnard the elements and an ephemeris for Comet Wolf 1884, the return of which is expected during the coming summer or fall. Mr. Barnard has through the medium of the Astronomical Journal put these data in the possession of American observers, and I see that the ephemeris has been printed in the April MESSENGER.

The changes in the elements due to the action of the planets have been very small. The longitude of the node has been lessened only 17″, the longitude of the perihelion increased slightly over 6′, the inclination decreased 1′, the angle of excentricity made small by about 16′, the mean daily motion shortened 3″.5, and the period of the comet augmented 6 days.

Professor Thraen has, from all the observations of the comet in 1884-5, made a careful determination of the orbit, the probable errors derived being quite small. I was apprehensive that an early ephemeris of the comet would not appear, and had from Thraen's elements computed an ephemeris for May and June next. I had just about completed my work when Mr. Barnard published Mr. Berberich's computation.

On comparison the places determined by the two sets of elements differ so slightly that mine would have served as a sweeping ephemeris.

It will be remembered that this comet was discovered by Dr. Wolf at Heidelburg, on September 17, 1884, when it was about ninety-four million miles from the earth, and last seen by Professor Young at Princeton, when it had increased its distance to 240 million miles. The comet is predicted to appear in the morning sky, rising on May 3d four hours before the sun, which is increased on July 6th to six hours.

The chances are exceedingly favorable for finding the comet at this return, and it is hoped that it will not elude the eyes of comet seekers as did Denning's of 1881, Barnard's of 1884 and Brorsen's. GEO. A. HILL.

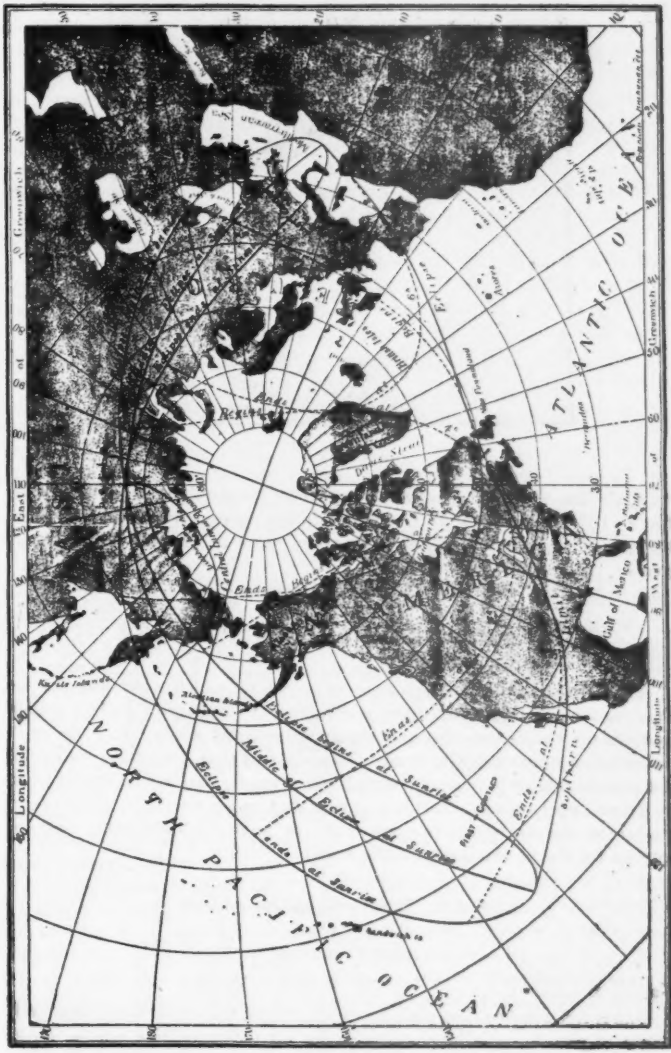
Naval Observatory, Washington, D. C., April 7, 1891.

A Total Eclipse of the Moon will take place on May 23d, beginning at $3^h\ 36^m$, and ending at $9^h\ 23^m$ Greenwich mean time. It will be invisible in the United States, but may be seen generally throughout the western part of the Pacific Ocean, Australia, Asia, Africa and Europe.

An Annular Eclipse of the Sun will occur on June 6. The moon will be so far from the earth at that time that its shadow will fail to reach the earth. An observer standing upon the earth directly under the apex of the shadow, would at the middle of the eclipse, see the moon upon the face of the sun surrounded by a very narrow ring of bright light. The difference between the diameters of moon and sun at that time will be only 11″.

Unfortunately for us the central line of the eclipse will pass very near the north pole, crossing the Arctic Ocean and touching land only in the northern part of Siberia. The portions of the earth where the eclipse will be partial are shown upon the chart on page 243. The line of the southern limit of the eclipse passes across the United States from the western part of Texas to the west of Lake Erie, through Canada, between Newfoundland and Labrador, across the Atlantic and the northern part of Spain, touching the northernmost part of Africa. The looped curves on the chart show the places where the beginning, middle and end of eclipse occur at sunrise and sunset. Between these loops and the southern limit of eclipse the reader will notice some dotted curves which show where the eclipse begins or ends at certain hours of Greenwich mean time. In the Eastern part of the United States the eclipse will be wholly invisible. At Chicago it will last only 25 minutes, beginning at $9^h\ 12^m$, and ending at $9^h\ 37^m$ central time. At Carleton College Observatory the eclipse will be a little larger, beginning $8^h\ 45^m$, and ending at $10^h\ 8^m$ central time. The magnitude of the eclipse, *i. e.*, the portion of the solar disk which will be covered by the moon is shown in the accompanying cut, Fig. 2. The moon will be seen to touch

ANNULAR ECLIPSE OF THE SUN, JUNE 6, 1891.



NOTE:—The hours of beginning and ending are expressed in Greenwich mean time.

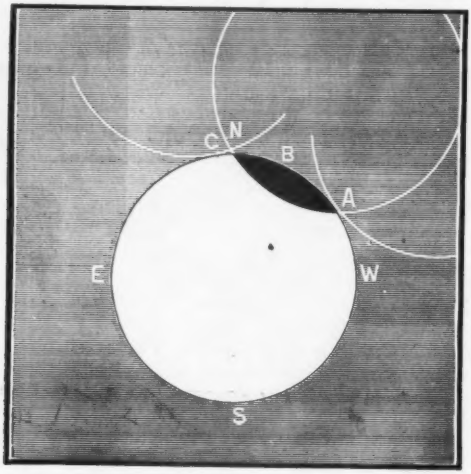


FIG. 2.

the sun's disk first at A, about 55° west from the north point, and to leave it at C, 10° east from the north point. In the western part of the United States, and especially in Alaska, the obscuration of the sun will be much greater.

AMATEUR STUDY AND OBSERVATION.

This issue contains a large amount of matter which is presumed to be useful to the amateur. Attention is called to Mr. Updegraff's paper which students may easily master, and should thoroughly study. G. P. Serviss' article below opens a field of study in astronomy that ought to give useful and pleasurable employment to hundreds of young people who have access to a good opera-glass. It is not saying too much to claim that every teacher of elmentary astronomy ought to have an opera-glass, and to practice its use in the study of the stars.

Among the Stars with an Opera-Glass.

GARRETT P. SERVISS.

FOR THE MESSENGER.

I have frequently taken pleasure in witnessing the mingled surprise and delight of persons who have accepted my invitation to look at the stars with an opera-glass, a thing they had never thought of doing, although the opera-glass had been their familiar companion at the theatre or the race track. It hardly needed the many letters I have received from readers of

"Astronomy with an Opera Glass," acknowledging that a new source of intellectual entertainment had been opened to them, to convince me that the powers of this simple instrument in celestial observation are as little suspected by most persons as they are surprising to those who try them for the first time. Take the simple fact that the number of stars visible to the naked eye on a clear night averages only about 3,000 at the most, while at the same time a powerful opera-glass, or field-glass, will reveal about 60,000 and nothing more needs to be said to demonstrate the value of such an aid in star-gazing. It is therefore with a full conviction that the result to be attained is worth the labor it costs that I have undertaken, at the request of the editor of THE SIDEREAL MESSENGER, to point out some of the things that the observer with an opera-glass may expect to see, and some of the things he should look for.

Many persons, it must be admitted, are satisfied after their first wondering glance at the starry riches that lie hidden in certain places in the heavens, and care no more about the matter. What I am about to write is not intended for them. Enthusiasm is as necessary to the observer with a mere opera-glass as to him who uses a powerful telescope. He must find his reward in his work. In that spirit one can go out under the dome of night with his glass, and study the wonderfully varied colors and tints of the stars, the striking contrasts of near neighbors in the celestial ranks, and their curious groupings, with undying delight. To him Sirius and Aldebaran and the Pleiades become more than mere names. His mind gradually opens to the sublime truth contained in that line of Aratus:

"From all quarters Heaven speaks to man."

It is important, in the first place, to choose a good opera glass. Not only should it be achromatic, but it should be large enough not to be ranked as a mere toy. If the observer does not mind the expense he should purchase a glass for the express purpose of star observations, and he will find that it answers all the other purposes of an opera-glass far better than the ordinary instruments sold under that name. The object lenses should not be less than an inch and a half in diameter. Two inches is a much better size. The magnifying power for a two-inch glass should be four or five diameters. With such a glass splendid views can be obtained of the richer parts of the Milky Way, and of such stellar assemblages as the Pleiades, the Hyades, and the star swarms around the Belt of Orion and α Persei. If possible a strong field-glass should also be at hand for the observation of some of the wider double-stars, and clusters too dense to be well seen with the weaker instrument.

During the month of May the constellations best placed for observation are Boötes, Virgo, Coma Berenices, Hydra, Corvus, Crater and Leo. To these may be added early in the month Cancer and Gemini, and perhaps Auriga and Canis Minor, and late in the month Libra, Corona Borealis, the head of Serpens and Hercules. Of the circumpolar constellations Ursa Major is too near the zenith, and Cassiopeia and Cepheus too near the horizon to be conveniently studied with the opera-glass; but Ursa Minor and Draco are very well situated. The amateur who is not familiar with the face of the sky should furnish himself with a series of maps of the constellations, or with a planisphere which may be purchased for a few shillings.

Suppose the observer begins with Leo, which lies on the meridian about eight o'clock at the beginning of the month. One of the most interesting things to be seen here is the decided difference in color between Regulus and Gamma Leonis, which comes out well with an opera-glass. Three minute stars near Zeta Leonis make a very pleasing little group with their larger neighbor. The eighth magnitude star about five minutes of arc south of Denebola is well worth searching for with a strong glass. No mere toy opera-glass will show it.

The star cluster in Cancer, called the Manger, is one of the best objects for the opera-glass. Galileo was able to count thirty-six stars in this cluster.

In Gemini there is a mine of starry wonders, particularly where the foot of the constellation meets the Milky Way. I have turned again and again with ever-renewed pleasure to the cluster 35M and the delicate star-streams around it.

Auriga is also a very rich constellation, containing several condensed assemblages of small stars that affect the naked eye like patches of faint light, but become very beautiful groups of stars when viewed with a glass. There are two or three catalogued star clusters in this constellation that can be recognized with a good field-glass.

Beginning with the striking group of stars under Cancer that marks the head of Hydra the observer can profitably follow out the long crooked course of this imaginary serpent, crossing the whole breadth of the southern sky and ending in the east under Virgo. The deep color of its chief and only conspicuous star, Alphard, commands admiration. Corvus and Crater, particularly the former, have some interesting star groupings, which I have pointed out elsewhere, and which the reader can easily find for himself.

The most interesting thing in Virgo at present is the planet Uranus, which can be easily seen with a strong opera-glass and readily identified after a few evenings of watching when its motion among the small stars near it becomes apparent. The observer can find out where to look for the planet by consulting the little chart of its path given in THE MESSENGER for March, p. 142. Having located the planet as near as may be in this manner, let him make a little chart of the stars visible with his glass, including the one which he suspects to be the planet. Repeat this charting on several successive evenings, or at intervals of two or three nights, and in a very short time, the identity of Uranus will become apparent. Moreover in this way the amateur observer will obtain a valuable object lesson in star charting which will be of great value to him in all subsequent observations. There is a charm, too, in the recognition, in this manner of the motion of a slow-moving planet like Uranus, that is as indescribable as it is delightful. One thus enjoys a touch of the same sort of pleasure that comes to the discoverer of a new planet.

Spica, the chief star of Virgo, is an admirable object when viewed with any kind of a glass. The purity and beauty of its white rays are almost unrivalled in the heavens.

Turning from Spica to Arcturus, the great yellow star in Boötes, is like passing from one range of the universe to another. There could hardly be

a more striking contrast. I call Arcturus yellow, and yet in certain circumstances of atmosphere and position its color is decidedly reddish. It is very beautiful in the glass and the tiny stars that twinkle here and there through the glare of its powerful rays add much to the beauty of the spectacle.

Berenices' Hair, or Coma Berenices, is a most beautiful little constellation for the opera glass observer. It would be an excellent exercise for him to make a chart of the stars that he is able to recognize in this remarkable assemblage, showing their comparative brightness as nearly as possible.

In Libra the star Alpha is one of the neatest doubles for opera-glass observation to be found in the sky. The peculiarity of color in Beta should be carefully studied.

In Hercules look particularly for the celebrated globular cluster between the stars Eta and Zeta. A good opera-glass readily shows it as a curious speck of light lying nearly on a line joining two little stars.

Directions for Copying and Using the Perpetual Calendar.

R. W. McFARLAND.

FOR THE MESSENGER.

Take a half sheet of foolscap, rule it lengthwise, as on p. 131, March number of THE MESSENGER. Let the spaces be half an inch wide, and extend to about two inches from the top. Set off seven inches for the lower set of figures, three-fourths of an inch each for old style and new style, and one inch and a half for the days of the month. Write out all the figures as they stand on p. 131, putting the heavy-faced type and 1800 new style in *red ink*. Cut a strip one inch and a half wide lengthwise from another half sheet; and rule three sets of spaces each half an inch wide, the short way of the slip. In the middle set write out the days of the week and the months as they stand on the upper part of p. 131. Then write the days of the week in the regular order in the upper and lower thirds of the slip, but omit the months. This gives the week three times and the months once. In the large sheet, at the place corresponding to the upper line of the blocks containing "Sun." and "Jan., Oct.," p. 131, cut a slit a little more than an inch and a half long: cut an equal parallel slit half an inch above the first. In like manner cut two slits below, the inner one corresponding to the line below "Sat." and "April, July" on p. 131. Draw the slip through these four slits, and place the middle third so that the sheet will in every respect be as the printed page above referred to. The calendar is then complete and ready for use, at an expense of half a cent or less.

Write the words "*Old style*" and "*New style*" in the proper places. The three sets of the days of the week are for the convenience of the one using the calendar.

To Set the Calendar for January, 1891.

Pull the slip down till Jan. stands opposite 91, in the lower block of figures. Then you see that the 1, 8, 15, 22, and 29 fall on Thursday.

To Set the Calendar for July, 1891.

Draw the slip upwards till July is opposite 91, then the 1, 8, etc., fall on Wednesday; the 2, 9, etc., on Thursday, etc.

The calendar is based primarily on the present century, and the only thing to do is to put the month opposite the required year. That operation sets the calendar not only for the present century, but for all others which fall into the same column with 1800 new style, viz., 2200, 2600, etc., also 200, 900, 1600, etc., old style.

Examples.

What day of the week will June 3, 1895, be?

Solution: Put June opposite 95; Monday is the 3d. So Monday will be the 3d for 2295, 2695, etc., new style, and for June 3d in the years 295, 995, 1695, etc., old style.

Remark: For January and February in any *leap year* in both styles set Jan. or Feb., as the case may be, against the figures in *red ink*. *Use the red ink numbers in no other months whatever.*

Required the day of the week for Feb. 22, 1840.

Solution: Put February opposite the *red ink* 40; the 22d was Saturday.

Required the day of the week for July 4th, 1840.

Solution: Put July opposite the other 40, and the 4th was also Saturday.

For Other Centuries.

First set the calendar as above directed; notice what day of the week is opposite 1800 new style; then draw the slip so as to put that day of the week opposite the required centesimal year.

Example: What day of the week was the 4th of July, 1776?

Solution: Put July opposite 76, Tuesday is opposite 1800; draw the slip up or down till *some* Tu. is opposite 1700 new style. In this case draw it down, otherwise the slip will be drawn out of its place. The 4th is Thursday.

Required the day of the week for Feb. 22, 1732, new style.

Put Feb. opposite the *red ink* 32; then Sat. is opposite 1800; draw the slip so as to put Sat. opposite 1700 new style. The 22d was Friday. Two or three more examples may suffice.

The reformation of the calendar by Gregory was in 1582; the last day of the old style was Oct. 4, 1582. Required the day of the week. Set Oct. opposite 82; Wed. is opposite 1800; draw the slip so as to put Wed. opposite 1500, old style. The 4th was Thursday. The next day was the first day of new style, but it was called Oct. 15th. Of course it was Friday, but find it by the calendar. Thus, set Oct. as before opposite 82, Wed. is opposite 1800; set Wed. opposite 1500 *new style;* the 15th was Friday.

By their own account the Pilgrims landed on the 11th of December, 1620. But the count was by old style. What day of the week was it? Put Dec. opposite 20, then Mon. stands by 1800. But 1600 old style is in the same column with 1800, and the slip must not be moved. The 11th was Monday. Change that date to new style. Set the calendar as before, and draw the Mon. opposite 1800 down to 1600 new style. The Mondays of that month were 7, 14, 21, and 28.

As a last example, required the day of the week for July 4, one thousand years in the future. Put July opposite 91, Sat. stands opposite 1800; draw the Sat. down to 2800 new style, and the 4th is on Wednesday.

A practice of half an hour ought to render any intelligent person master of this calendar so that any date in either style can be found in a minute. An experienced operator can find any date in either style in 5 seconds.

In order to use this calendar it is not necessary that the operator know anything about the history of chronology, any further than it is given in this paper. And I have thought it unnecessary to write any of that history.

How to Observe Variable Stars. We have asked one or two of the best observers of variable stars that we know of in this country to give suggestions for amateur work in this direction. Some useful work will be mapped out next time.

NEWS AND NOTES.

Scientific Control of the Naval Observatory. It is noticeable recently that the opposition to the transfer of the management of the Naval Observatory to scientific control comes from persons who say that astronomers want this change because of recent complications in the standard time question. While it is true that astronomers generally are of the opinion that the posititon of the Naval Observatory in regard to the standard time has been, and is, wrong and unjust, that is not the point at issue with them. They claim that the national Observatory is a scientific institution,—that and nothing less, and because its character is such, it ought to be under scientific control. Astronomers everywhere should be on their guard and not let the discussion be turned from the main issue.

Triangulating in Coma Berenices. Dr. W. L. Elkin, of Yale University, is now carrying on the triangulation of the principal stars in Coma Berenices by the aid of the heliometer. By his request observations of the *relative positions* of some of these stars are being made by the Meridian Circle at Carleton College Observatory to aid Dr. Elkin in this another important piece of his heliometer work.

School of Practical Astronomy and Mathematics. By reference to announcement elsewhere given, it will appear that the advantages for study in post-graduate lines will be considerably extended during the coming year. Students or teachers having completed the ordinary college course, and desiring better knowledge of the branches of mathematics and astronomy, are respectfully asked to consider the facilities now offered by Carleton College Observatory in these special lines. The new astronomical instruments that will be in place next month, and the various kinds of original practical work already begun will suggest the rare opportunities for study offered at this institution. For particulars correspond with the Director of the Observatory.

New Rooms for the Astronomical Society of the Pacific. On the evening of March 28 the Astronomical Society of the Pacific held its second annual meeting in the new rooms allotted to it, in the new building of the California Academy of Sciences, located on Market street, San Francisco. In one of the local papers of March 29 we notice the following statement: "Mr. Charles Burckhalter, secretary, read the proceedings of the Board of Directors, among which were acts relating to the distribution of the Donohoe Comet medal, by which the laws governing its award were considerably modified. It appeared that although the medal had been earned six times since its foundation, it was only accepted by five of the discoverers since Professor Barnard of Mount Hamilton, who had all along contended that the reward should not attach to the re-discovery of periodic comets, chose the occasion of his finding d'Arrest's comet last year to refuse the medal, and to request that the conditions be changed. It will now be given only for the first discovery of a periodic comet, and not for its earliest detection at a subsequent return. The dates of the Mount Hamilton meetings are also changed, making these come but twice during the year.

Solar Disturbances and Terrestrial Magnetism. Last month a private letter of unusual interest was received from T. S. H. Shearmen of Brantford, Canada, in which he speaks of the fact that Professor Young has recently called attention to the re-discovery in the United States, that there is a connection between the visibility *from the earth* of solar disturbances and terrestrial magnetism. Mr. Shearmen claims that he detected the relation in question nine years ago, and that he secured the right to the discovery by publishing an account of his conclusions in a newspaper under a *nom de plume*. The reasons for so publishing the account seemed to him good at the time, and we do not wonder at his course as explained.

The announcement was published in the London (Canada) *Free Press*, Nov. 27, 1882, a copy of which is believed to be still on file in the office of publication. We have asked Mr. Shearmen to give our readers an account of his discovery.

Washington Magnetic Observations for 1888-89 is a volume of 100 pages accompanied by fourteen large maps giving automatic records of instruments. This volume contains a brief description of buildings, instruments, observations, manner of reducing them, personnel, explanation of tables and plates. Then follows the tabulated observations which occupy about nine-tenths of the book.

Carleton College Observatory Library has been favored by copies of publications from the Royal Observatory of Greenwich, as follows:

Greenwich Magnetical and Meteorological Observations for 1888.

Greenwich Astronomical Results for 1888.

Greenwich Spectroscopical and Photographic Results for 1888, and also for 1889.

These are valuable records.

Errata. In April number of MESSENGER, line 13, page 171, 0".8 should read 0".08. In January issue, page 6, line 10, from bottom η should read ζ.

Emersion of Rhea from an Eclipse. On the evening of Wednesday, April 8th, while looking at Saturn with a friend, we noticed that Rhea was missing, and on examining the ephemeris found that the satellite must be either behind the planet, or else immersed in its shadow.

At $8^h\ 56^m.0$ [Eastern Standard Time], she reappeared rather suddenly, about 3″ from the planet's eastern limb, and opposite the parallel of 60° or 70° of south latitude. At first the satellite was very faint, but it rapidly brightened, and in about three and a half or four minutes had recovered its normal brilliance; this would indicate for it a diameter of from twelve to fifteen hundred miles. The eye-piece was an achromatic giving a power of about 500.

At this time Tethys was approaching its northern conjunction with the western extremity of the ring, and Enceladus was skirting the southern edge of the eastern ansa; both of them apparently very closely on time. Mimas was not seen, and according to the ephemeris was then on the planet's disc.

The seeing was only fairly good, so that the Cassinian division was visible only at the ends of the ring, and was not very easy to make out even there. The gauze ring was well seen in the ansæ, but where it crossed the ball was lost in the shadow of the other rings. The planet's belts were conspicuous, but no spots were visible upon the disc. At times the so-called "square-shouldered" form of the ball was rather striking; but on hiding either end of the ring behind an occulting bar, the appearance vanished on that side of the planet, showing the peculiarity to be a mere illusion, due to the cutting down of the irradiation of the equatorial diameter of the planet by the brightness of the adjacent part of the ring.

Princeton, N. J., April 10, 1891. C. A. YOUNG.

New Annalen der K. Sternwarte in Bogenhausen bei Munchen. This publication is issued under the direction of Hugo Seeliger and is the first volume of the new series. It is a volume of 717 pages of large quarto form, and contains a catalogue of 33082 stars, ranging in magnitude usually from 7 to 10. Each page has ten columns with heads, as follows: star number, magnitude, right ascension for 1880, No. Obs., precession for 1880, declination for 1880, No. Obs., precession, epoch, and reference catalogues. This volume has a full introduction giving a description of instruments and methods of reduction.

Standard for Wave-Length in the Spectrum Analysis. In April *Observatory* (English) is a brief, incisive letter by Dr. J. Scheiner, on the standard of wave-lengths to be used by practical workers in spectrum analysis. It was written chiefly to answer one point of criticism by Miss Clerke in these words: "Unfortunately, however, the wave-lengths are given in a Potsdam scale, the introduction of which is equally unnecessary and undesirable. Angström's scale can not, of course, be permanently retained, but Rowland's is its destined successor, and the multiplication of standards should be strenuously resisted." On this point Dr. Scheiner says: "I should like to hear upon what grounds Miss Clerke bases the inference that Rowland's tables are to be the successors of Angström's? Upon ground, I

fear, artistic rather than scientific. There can be no doubt that Rowland's tables are finer than the Potsdam ones, nor that they are the best which exist, unfortunately Professor Rowland has not given a *Catalogue of all his lines from exact measurement of the negatives.* The wave-lengths from the Rowland tables can be employed for many purposes but not for all—for example, for the reduction of photographic stellar spectra, they are not sufficiently complete. The Potsdam wave-lengths can be employed for *all* purposes. I know no other catalogue of such completeness. Moreover, the Rowland standards have been changed from time to time, and there is no publication which makes directly evident the method by which the Rowland standards were calculated. They all depend on the wave-length of one single line."

In comparing the Rowland Chart and the Potsdam Catalogue, Dr. Scheiner thinks they are like a fine chart of the heavens and a meridian catalogue of stars. The chart is indispensible for orientation, and useful in some cases for positions, but generally the catalogue must be consulted for positions. He says he has advised, in his new book, the use of the one for orientation, the other for calculation, and that the constant differences between Rowland and Potsdam are small and that there is no difficulty in finding Rowland's lines from Potsdam's wave-lengths. Dr. Scheiner holds the common view, that "the multiplication of standards should be strenuously resisted."

Accurate Measures by Mr. Keeler. Some very astonishing facts appear in the study of Mr. Keeler's work with the spectroscope at Lick Observatory. His own general statement will indicate something of what we mean. He says that he would "with some confidence undertake to determine the month of the year, by measuring the distance of the principal line (in the spectrum of the nebula of Orion) from the lead-line used in the comparison spectrum.

Professor John Haywood, Otterbein University, Westerville, Ohio, on the evening of April 10, observed an unusual display of faculæ near the eastern limb of the sun, and on the southern spot zone.

Peculiar Star Occultation. On the evening of April 11, I observed the immersion of a star in Taurus, 6.5 or 7 magnitude, 60° from the north point, 10° from the vertex. The star disappeared at $8^h\ 10^m\ 1^s$, Central standard time; re-appeared and disappeared again about one second after the first disappearance. The moon's altitude was 20°, the definition in the vicinity of the moon was unsteady; the details of the moon would be very distinct for an instant, then blurred. It would thus seem that the action of the earth's atmosphere would account for the above double disappearance.

J. A. PARKHURST.

U. W. Lawton, Jackson, Mich., in a recent private letter gives an interesting account of the new small Observatory that he is erecting at the above named place.

Observatory at Dakota Agricultural College. We admire the earnest purpose of President Lewis McLouth, Agricultural College, Brookings, Dakota, in bringing that institution promptly to the front rank in general scientific work. He has already ordered an astronomical outfit from Mr. G. H. Sægmuller of Washington, D. C., consisting of a five-inch equatorial telescope with driving-clock, micrometer, etc., 2-inch transit instrument, clock and chronograph. He purposes to build a small Observatory and to determine his longitude early this summer.

Photographic Notes. The Report of the Washington University eclipse party contains much of interest on the photographic work done at the time of the eclipse on Jan. 1, 1889. The method of exposure and careful manipulation in development are described with interesting detail. Professor Charropin states that the protuberances are found to contain more actinic rays than the corona. Professor Pritchett calls attention to the fact that negatives of short exposure are characterized by sharp definition of the polar filaments, while those of longer exposures show the streamers of the outer corona. He closes his report with the following statement: "The testimony of the negatives of the corona of January 1889, is to confirm the opinion already held that there is a characteristic form of the corona corresponding to periods of sun-spot maxima and minima." Artotypes of five of these negatives are published with the report.

The Scientific American of April 11 devotes three columns to an article by Nicolas Pike on "Photography as it was and is." Mr. Pike traces in an interesting and concise way the history of photography from the time of Baptista Porta, who discovered the camera obscura in the sixteenth century. Of especial interest are his statements in regard to the photography of color, past and present. Sir John Herschel is named as being undoubtedly the first discoverer of a method for color photography; at about the same time Sir Robert Hunt secured many colored pictures of the spectral rays, dark upon a bright ground; ten years later M. Edmund Becquerel produced on metallic plates the colors of the spectrum. In 1856 Mr. Pike visited Dr. Diamond, of Surrey, England, of whose pictures he says: He showed me the only good picture I have ever seen made with a camera and lens in colors. It was a view of an old fashioned, two-story, frame clapboarded house, with moss and lichens in many places over the doors and windows. The picture was partly colored, the lichens showing their yellow and gray markings, and the house of a dark brown color. It was very pretty but the doctor said it was taken while he was experimenting, and he could not account for it."

Mr. F. Bligh Bond of Bristol has on exhibition a colored photograph of Land's End said to have been taken directly from a set of three negatives; it is printed in blue, carmine and yellow.

Professor Lippmann's claims to the production of color films are seriously doubted by the British Journal of Photography.

Mr. Ranyard made the following statements before the Royal Astronomical Society: "We cannot rely upon the star images being condensed in the same way by different object-glasses, or even with the same object-glass on different parts of the plate. The rapidity of the photographic ac-

tion is intimately associated with the way in which the light from a luminous point is collected into a point or a patch on the sensitive plates. There is also a great difference in the transparency of the air for the photographic rays from hour to hour; so that we shall not be able to rely on star magnitudes derived from the duration of the exposure."

At the Greenwich Observatory the following plates have been tried in astro-photographic work: Wratten and Wainright, Seed Company, and Star; a slight preference is expressed for the Star plates.

Speaking of change in the transparency of the air Mr. Roberts says: "The companion of Polaris is about the 9th magnitude. I have been able to photograph it on some nights in a single second, and at other times it takes a minute.

Meeting of the Astronomical Society of the Pacific, March 28, 1891.

The Society met for the first time in the lecture hall of the new building of the California Academy of Sciences, President Holden in the chair.

The thanks of the Society were returned to the California Academy of Sciences for their invitation to hold its San Francisco meetings in the lecture hall of the Academy building, and the invitation was accepted.

At the meeting of the Directors, held in the society's rooms, twenty-one members were elected as follows:

Miss Elizabeth H. Pearson, No. 219 Savin Hill avenue, Boston, Mass.; Lewis A. Pagin, No. 122 South Market street, Chicago, Ill.; A. L. Smith, No. 23 Washington street, Chicago, Ill.; Francis G. Du Pont, Wilmington, Del; Mrs. Sarah B. Gamble, No. 1222 Pine street, San Francisco; Joseph B. Walker, Geological Survey, Austin, Tex.; Miss Estella Guppy, San José, California; Oliver E. Pagin, Room 40, United States Custom House, Chicago, Ill.; F. S. Archenhold, 57 Invaliden strasse, Berlin, Germany; S. Wilson Fisher, 1502 Pine street, Philadelphia, Pa.; Camilo Martin, 411½ California street, San Francisco; Charles T. Blake, Berkeley, Cal.; L. J. Holton, 1207 Seventeenth street, Alameda, Cal.; Harry W. Syz, 410 California street, San Francisco; C. B. Kendall, 137 Montgomery street, San Francisco; California Camera Club, 819 Market street, San Francisco; Professor Meller W. Haskell, University of California, Berkeley; Archer B. Pierce, University of California, Berkeley; William Sturtevant Harlow, Oakland, Cal.; A. R. Blake, Berkeley, Cal.; T. C. Johnson, 27 Market street, San Francisco.

Mr. H. F. Newall, Observatory, Cambridge, England; J. C. Cebrian and Dr. J. Callandreau, of San Francisco, were elected life members.

At the regular meeting, the committee on nominations reported the following names for Directors and Committee on Publication:

For Board of Directors—Wm. Alvord, Charles Burckhalter, Chas. B. Hill, S. G. Hillborn, E. S. Holden, James E. Keeler, E. J. Molera, Wm. M. Pierson, J. M. Schaeberle, Frank Soulé, F. R. Ziel.

For Publication Committee—E. S. Holden, James E. Keeler, Chas. G. Yale. The ticket was unanimously elected, Messrs. McConnell and Veede acting as tellers.

The Treasurer made the following report:

Receipts for the year, - - - - - - -	$1,980.63
Expenditures for the year, - - - - -	2,347.89
Cash in bank, - - - - - - -	744.65

Over $1,000 is still due from members for dues for the present year.

The above expenditures do not include the amount expended for the Library.

The Alexander Montgomery Library Fund of the Society shows $1.590 and the Donohue Comet Medal Fund $527, both the above funds being in savings bank bearing interest.

The Library Committee reported that the library has 491 volumes, 431 of which were purchased from the Montgomery Library Fund. The cost of the library to date has been $1,017.50, and non-resident members may draw books by mail—the member withdrawing the books paying the postage.

The Committee on Comet Medal reported that five medals had been awarded as follows: To Messrs. BROOKS, COGGIA, DENNING, SPITALER and ZONA, for comets *a*, *b*, *c*, *e* and *f*, 1890. The medal is awarded only for unexpected comets.

Article IX. of the by-laws was changed so that hereafter there will be two meetings at the Lick Observatory each year, viz., the second Saturday in June and the first Saturday in September.

A committee consisting of Professor G. W. Hough, G. E. Hale, G. A. Douglas and R. W. Pike, of Chicago, Wm. M. Pierson and C. B. Hill, of San Francisco, and A. J. Burnham, of Lick Observatory, was appointed to make arrangements for an astronomical exhibit at the Columbian Exposition in Chicago.

The following papers were announced:

a. The Fireball in Raphael's Madonna di Foligno, by Professor H. A. Newton, Yale University.

b. On the Similarity of Certain Orbits in the Zone of Asteroids (second paper) by Professor Kirkwood, Riverside.

c. Astronomical Observations in 1890, by Torvald Kohl, Denmark.

d. Address of the Retiring President of the Society, by Professor Holden, Mt. Hamilton.

e. A few Hints to Beginners in Solar Observations, by Miss E. Brown, of England.

f. Lunar Work for Amateurs, by Thomas Gwyn Elger, F. R. A. S., of England

g. The Total Solar Eclipse of January, 1889, by Professor H. S. Pritchett, Washington University, St. Louis.

The chairman announced the presence of Lord Rosse. The Earl was introduced and said that he did not propose to read all the papers that he had before him, but would make a few remarks about reflecting telescopes. He said that he had worked with reflectors and was naturally a special pleader in their favor. He had just seen the great refractor at Mt. Hamilton and was much pleased with it. A three-feet reflector can be built for less money than a three-feet refractor. The one built by his father has a diameter of six feet. Before claiming any advantage each should be tested and given a fair trial. His telescope was made by native workmen. It is naturally inferior to what could be made to-day. His father's idea was to follow Sir William Herschel and sweep the heavens and resurvey the 2000 nebulæ in his catalogue. One of the great advantages of a large object glass is to furnish so much light to the eye as to enable us to see objects which could not be seen otherwise. When it comes to work with a spectroscope, or when you want to photograph a nebula, an instrument

made fifty years ago requires some changes. There is some trouble in keeping the speculum in place, but the trouble is purely mechanical. It is difficult to compare reflectors with refractors. In the case of photography, with the refracting telescope you cannot get the rays to blend together. This trouble does not exist with the reflector. We should give the reflector a fair trial. In Paris two years ago it was decided that reflectors were best for photography. In measuring the heat from the moon the reflector will do the best work. He was astonished to see the number of people visiting the Observatory at Mount Hamilton. In England no such interest is manifested.

The thanks of the society were given to the Earl of Rosse for his explanation of reflectors. Professor Holden said that when the great telescope was finished at Washington it was his work to go over the observations of Sir William Herschel and he had compared his with those of Lord Rosse and had found his work absolutely correct. The reflector has a priceless advantage for photography. The question of supporting the speculum is purely mechanical. In spectroscopy and photography the reflector is the best, but there is a place for both side by side.

The President's report was read, showing that the society started two years ago with 40 members, and now had 380.

The society has members in twenty-six states of the Union, and nineteen foreign countries. There are 42 life, and 338 active members.

After the regular meeting the newly elected directors held a meeting at which the following officers were elected to serve for the ensuing year:

Wm. M. Pierson, president; Frank Soulé, J. M. Schæberle, E. J. Molera, vice-presidents; J. E. Keeler, Charles Burckhalter, secretaries; F. R. Ziel, treasurer.

The next meeting will be held in the library of Lick Observatory, June 13th.

CHAS. BURCKHALTER,
Secretary.

BOOK NOTICE.

Elements of Plane and Spherical Trigonometry. By Edward S. Crawley, Assistant Professor of Mathematics in the University of Pennsylvania. Publishers, Messrs. J. B. Lippincott Company, Philadelphia, 1890. pp. 159.

The aim of the author in this book has been to present that portion of the subject of Trigonometry which is generally given in a college course, in as clear and concise form as possible. The first part of the branch is worked out in detail carefully; later the student is thrown upon his own resources, the object being to develop him in the power of making intelligent use of the materials found in the earlier part of his course. In the chapter on the solution of oblique spherical triangles two methods are given for each of the ordinary cases, one by Napier's Analogies, the other by means of a perpendicular. This is a useful feature. The grouping of most important formulæ at the end of the book is also very desirable. The book is well planned for the use of the class-room, and it appears in an orderly, neat and easy typographical dress which its publishers know how so well to furnish.

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4. Analytic Mechanics from texts-books by Wood and Bowser.
5. Practical and Theoretical Astronomy. Text-book by Loomis and Chauvenet.
6. Work with Astronomical Instruments, Transit, Meridian Circle and Equatorial.
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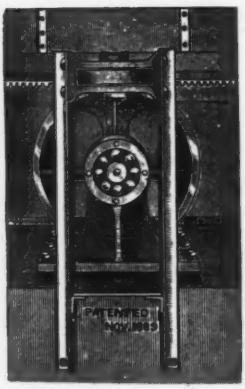

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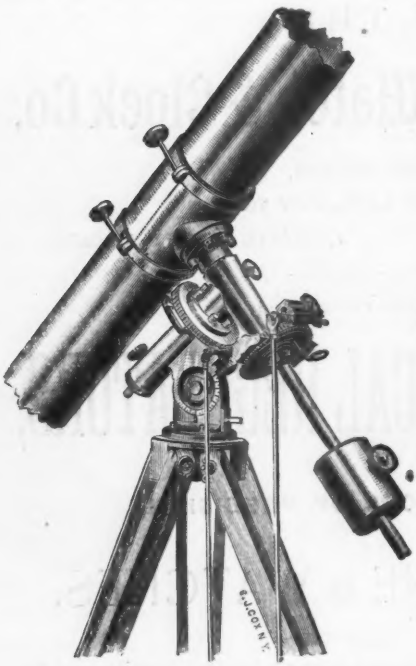

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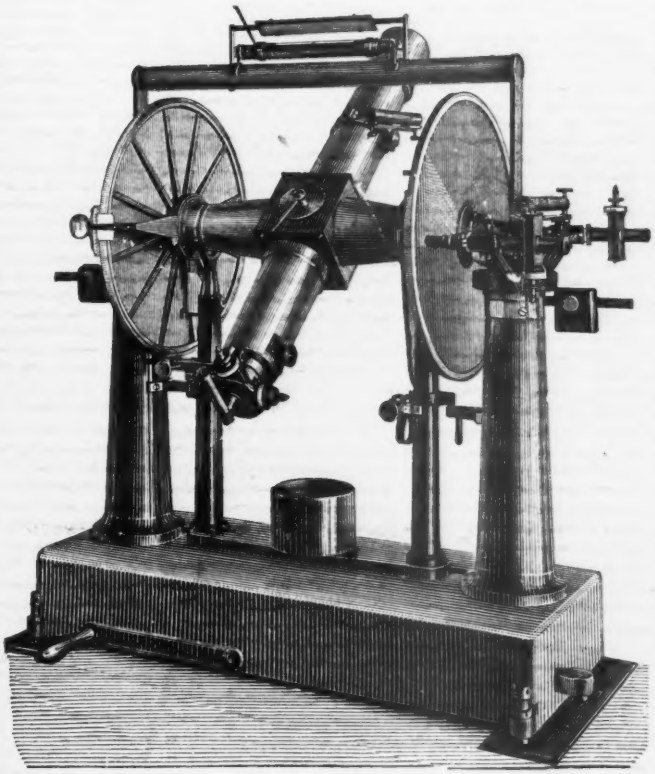

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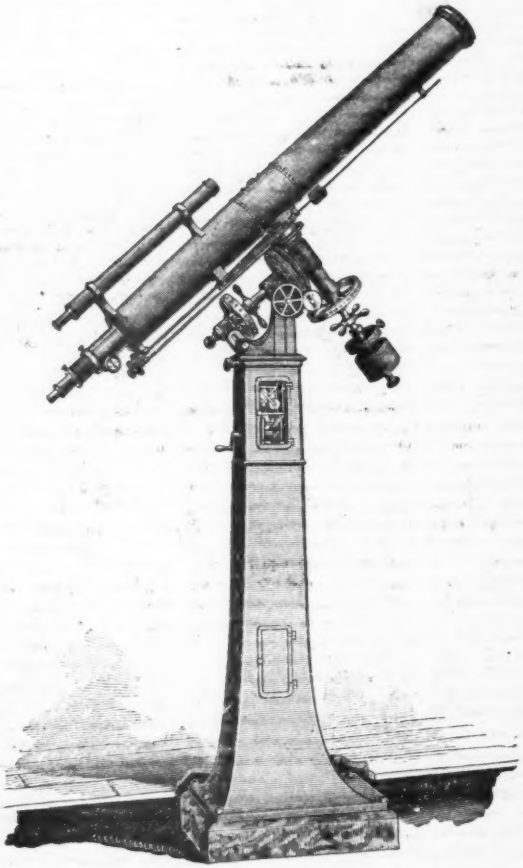

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